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Product Environmental Footprint (PEF) Guide

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European Commission (EC)

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Contents

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Executive Summary

The Product Environmental Footprint (PEF) is a multi-criteria measure of the environmental performance of a good or service throughout its life cycle. PEF information is produced for the overarching purpose of seeking to reduce the environmental impacts of goods and services taking into account supply chain[1] activities (from extraction of raw materials, through production and use, to final waste management). This PEF Guide provides a method for modelling the environmental impacts of the flows of material/energy and the emissions and waste streams associated with a product throughout its life cycle.

This document provides guidance on how to calculate a PEF, as well as how to develop product category-specific methodological requirements for use in Product Environmental Footprint Category Rules (PEFCRs). PEFs are complimentary to other instruments focused on specific sites and thresholds.

Context

This PEF Guide has been developed in the context of one of the building blocks of the Flagship initiative of the Europe 2020 Strategy – "A Resource-Efficient Europe."[2] The European Commission's "Roadmap to a Resource Efficient Europe"[3] proposes ways to increase resource productivity and to decouple economic growth from both resource use and environmental impacts, taking a life-cycle perspective. One of its objectives is to: "Establish a common methodological approach to enable Member States and the private sector to assess, display and benchmark the environmental performance of products, services and companies based on a comprehensive assessment of environmental impacts over the life-cycle ('environmental footprint')". The European Council invited the Commission to develop supporting methodologies.

Thus, the Product and Organisation Environmental Footprint (OEF) project was initiated with the aim of developing a harmonised European methodology for Environmental Footprint (EF) studies that can accommodate a broader suite of relevant environmental performance criteria using a life-cycle approach.[4] A life-cycle approach refers to taking into consideration the spectrum of resource flows and environmental interventions associated with a product or organisation from a supply chain perspective. It includes all stages from raw material acquisition through processing, distribution, use, and end-of-life processes, and all relevant related environmental impacts, health effects, resource-related threats and burdens to society. This approach is also essential for exposing any potential trade-offs between different types of environmental impacts associated with specific policy and management decisions. It thus helps to avoid unintended shifting of burdens.

[1] Supply chain is often referred to as "value chain" in literature. However, the term "supply chain" was here preferred to avoid the economic connotation inherent to "value chain".
[2] European Commission 2011: COM(2011) 571 final: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Roadmap to a Resource Efficient Europe.
[3] http://ec.europa.eu/environment/resource_efficiency/index_en.htm
[4] http://ec.europa.eu/environment/eussd/corporate_footprint.htm

Objectives and target audience

This document aims to provide detailed and comprehensive technical guidance on how to conduct a PEF study. PEF studies may be used for a variety of purposes, including in-house management and participation in voluntary or mandatory programmes. It is primarily aimed at technical experts who need to develop a PEF study, for example engineers and environmental managers in companies and other institutions. No expertise in environmental assessment methods is needed to use this Guide for conducting a PEF study.

This PEF Guide is not intended to directly support comparisons or comparative assertions (i.e. claims of overall superiority or equivalence of the environmental performance of one product compared to another (based on ISO 14040:2006)). Such comparisons require the development of additional PEFCRs that would complement the more general guidance given here, in order to further increase methodological harmonisation, specificity, relevance and reproducibility for a given product-type. PEFCRs will furthermore facilitate the focusing of attention on the most important parameters, thus also reducing the time, efforts, and costs involved in completing a PEF study. In addition to providing general guidance and defining the requirements for PEF studies, this document also specifies the requirements for the development of PEFCRs.

Process and Results

Each requirement specified in this PEF Guide has been chosen taking into consideration the recommendations of similar, widely recognised environmental accounting methods and guidance documents. Specifically, the methodology guides considered were: ISO standards[5] (in particular: ISO 14044(2006), Draft ISO/DIS 14067(2012); ISO 14025(2006), ISO 14020(2000)), the ILCD (International Reference Life Cycle Data System) Handbook[6]; the Ecological Footprint Standards[7]; the Greenhouse Gas Protocol[8] (WRI/ WBCSD); the general principles for an environmental communication on mass market products BPX 30-323-0 (ADEME)[9]; and the specification for the assessment of the life cycle greenhouse gas emissions of goods and services (PAS 2050, 2011)[10].

The outcome of this analysis is summarised in Annex X. A more detailed description can be found in "Analysis of Existing Environmental Footprint Methodologies for Products and Organizations: Recommendations, Rationale, and Alignment" (EC-JRC-IES 2011b)[11]. Whereas existing methods may provide several alternatives for a given methodological decision point, the intention of this PEF Guide is (wherever feasible) to identify a single requirement for each decision point, or to provide additional guidance that will support more consistent, robust and reproducible PEF studies. Thus, comparability is given priority over flexibility.

As elaborated before, PEFCRs are a necessary extension of and complement to the more general guidance for PEF studies provided in this document (i.e. in terms of comparability between different PEF studies). As

[5] Available online at http://www.iso.org/iso/iso_catalogue.htm
[6] Available online at http://lct.jrc.ec.europa.eu/assessment/publications
[7] "Ecological Footprint Standards 2009" – Global Footprint Network. Available online at http://www.footprintnetwork.org/images/uploads/Ecological_Footprint_Standards_2009.pdf
[8] WRI and WBCSD (2011). Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Standard, 2011.
[9] http://www2.ademe.fr/servlet/getDoc?id=11433&m=3&cid=96
[10] Available online at http://www.bsigroup.com/en/Standards-and-Publications/How-we-can-help-you/Professional-Standards-Service/PAS-2050/
[11] This document can be accessed via http://ec.europa.eu/environment/eussd/corporate_footprint.htm

they are developed, PEFCRs will play an important role in increasing the reproducibility, quality, consistency, and relevance of PEF studies.

Relationship to the Organisation Environmental Footprint Guide

Both the Organisation Environmental Footprint (OEF) and the PEF provide a life-cycle approach to quantifying environmental performance. Whereas the PEF method is specific to individual goods or services, the OEF method applies to organisational activities as a whole – in other words, to all activities associated with the goods and/or services the organisation provides from a supply chain perspective (from extraction of raw materials, through use, to final waste management options). Organisation and Product Environmental Footprinting can therefore be viewed as complementary activities, each undertaken in support of specific applications.

Calculating the OEF does not require multiple product analyses. Rather, the OEF is calculated using aggregate data representing the flows of resources and waste that cross a defined organisational boundary. Once the OEF is calculated, however, it may be disaggregated to the product level using appropriate allocation keys. In theory, the sum of the PEFs of the products provided by an organisation over a certain reporting interval (e.g. 1 year) should be close to its OEF for the same reporting interval[12]. The methodologies in this PEF Guide have been purposefully developed towards this end. Moreover, the OEF can help to identify areas of the organisation's product portfolio where environmental impacts are most significant and, hence, where detailed, individual product-level analyses may be required.

Terminology: shall, should and may

This PEF Guide uses precise terminology to indicate the requirements, the recommendations and options that companies may choose.

The term "shall" is used to indicate what is required in order for a PEF study to be in conformance with this Guide.

The term "should" is used to indicate a recommendation rather than a requirement. Any deviation from a "should" requirement has to be justified by the conductor of the study and made transparent.

The term "may" is used to indicate an option that is permissible.

[12] For example, a company produces 40,000 T-shirts and 20,000 pants per year with a product environmental footprint of X and Y for T-shirts and pants respectively. The OEF of the company is Z per year. In theory, Z = 40,000 x X + 20,000 x Y.

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1. General Considerations for Product Environmental Footprint (PEF) Studies

1.1 Approach and examples for potential applications

The Product Environmental Footprint (PEF) is a multi-criteria measure of the environmental performance of a good or service throughout its life cycle[13]. PEF information is produced for the overarching purpose of helping to reduce the environmental impacts of goods and services.

This document provides guidance on how to calculate a PEF, as well as how to create product category-specific methodological requirements for use in Product Environmental Footprint Category Rules (PEFCRs). PEFCRs are a necessary extension of and complement to the general guidance for PEF studies. As they are developed, PEFCRs will play an important role in increasing the reproducibility, consistency, and relevance of PEF studies. PEFCRs help focus on the most important parameters, thus also possibly reducing the time, efforts, and costs involved in conducting a PEF study.

Based on a life-cycle approach[14], the PEF Guide provides a method for modelling the environmental impacts of the flows of material/energy and resulting emissions and waste[15] streams associated with a product[16] from a supply chain[17] perspective (from extraction of raw materials[18], through use, to final waste management). A life cycle approach refers to taking into consideration the spectrum of resource flows and environmental interventions associated with a product or organisation from a supply chain perspective. It includes all stages from raw material acquisition through processing, distribution, use, and end-of-life processes, and all relevant related environmental impacts, health effects, resource-related threats and burdens to society.

It is primarily aimed at technical experts who need to develop a PEF study, for example engineers and environmental managers. No expertise in environmental assessment methods is necessary in order to use this Guide to develop a PEF study.

The PEF method is based on the life-cycle approach. The life-cycle approach to environmental management, and Life Cycle Thinking (LCT) in general, takes into consideration all relevant environmental interactions associated with a good, service, activity, or entity from a supply chain perspective. This is in contrast to focusing on site-level impacts only or on single environmental impacts in order to reduce the possibility of unintended burden shifting; shifting of the environmental impact burden from one stage in a supply chain to another, from one impact category to another, between impacts and resource efficiency, and/or between countries.

[13] The life cycle equals the consecutive and interlinked stages of a product system, from raw material acquisition, or generation from natural resources, to final disposal (ISO 14040:2006).

[14] A Life Cycle Approach takes into consideration the spectrum of resource flows and environmental interventions associated with a product from a supply chain perspective, including all stages from raw material acquisition through processing, distribution, use, and end-of-life processes, and all relevant related environmental impacts (instead of focusing on a single issue within the life cycle).

[15] Waste is defined as substances or objects which the holder intends or is required to dispose of. (ISO 14040:2006)

[16] Product – a good or a service (ISO 14040:2006).

[17] Supply chain is often referred to as “value chain” in literature. However, the term “supply chain” was here preferred to avoid the economic connotation inherent to “value chain”.

[18] Raw material – primary or secondary material that is used to produce a product (ISO 14040:2006).

In order to develop a model that provides a realistic representation of these physical flows and impacts, modelling parameters need to be defined, insofar as possible, based on clear physical terms and relationships.

Each requirement specified in this PEF Guide has been chosen taking into consideration the recommendations of similar, widely recognised product environmental accounting methods and guidance documents. Specifically, the methodology guides considered were:

- ISO standards[19], in particular: ISO 14044(2006), Draft ISO/DIS 14067(2012); ISO 14025(2006), ISO 14020(2000);
- ILCD (International Reference Life Cycle Data System) Handbook[20];
- Ecological Footprint[21];
- Greenhouse Gas Protocol[22] (WRI/ WBCSD);
- General principles for an environmental communication on mass market products BPX 30-323-0 (ADEME)[23];
- Specification for the assessment of the life cycle greenhouse gas emissions of goods and services (PAS 2050, 2011)[24].

Annex X provides an overview of some key selected requirements contained in this PEF Guide compared to the requirements/specifications contained in the abovementioned methodology guides. A more detailed description of the analysed methods and of the outcome of the analysis can be found in "Analysis of Existing Environmental Footprint Methodologies for Products and Organizations: Recommendations, Rationale, and Alignment".[25] Whereas existing methods may provide several alternatives for a given methodological decision point, the intention of this PEF Guide is (wherever feasible) to identify a single requirement for each decision point, or to provide additional guidance, in order to support more consistent, robust and reproducible PEF studies.

Potential applications of PEF studies may be grouped depending on in-house or external objectives:

- In-house applications may include support to environmental management, identification of environmental hotspots, and environmental performance improvement and tracking, and may implicitly include cost-saving opportunities;

- External applications (e.g. Business-to-Business (B2B), Business-to-Consumers (B2C)) cover a wide range of possibilities, from responding to customer and consumer demands, to marketing, benchmarking, environmental labelling, supporting eco-design throughout supply chains, green

[19] Available online at http://www.iso.org/iso/iso_catalogue.htm
[20] Available online at http://lct.jrc.ec.europa.eu/assessment/publications
[21] "Ecological Footprint Standards 2009" – Global Footprint Network. Available online at http://www.footprintnetwork.org/images/uploads/Ecological_Footprint_Standards_2009.pdf
[22] GHGP 2011, Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Standard.
[23] Available online at http://www2.ademe.fr/servlet/getDoc?id=11433&m=3&cid=96
[24] Available online at http://www.bsigroup.com/en/Standards-and-Publications/How-we-can-help-you/Professional-Standards-Service/PAS-2050/
[25] European Commission - Joint Research Centre - Institute for Environment and Sustainability (2011b). Analysis of Existing Environmental Footprint Methodologies for Products and Organizations: Recommendations, Rationale, and Alignment. EC – IES - JRC, Ispra, November 2011. http://ec.europa.eu/environment/eussd/corporate_footprint.htm

procurement and responding to the requirements of environmental policies at European or Member State level;

- Benchmarking could for example include defining an average performing product (based on data provided by stakeholders or on generic data or approximations) followed by a grading of other products according to their performance versus the benchmark.

Table 1 provides an overview of the intended applications of PEF studies in relation to the key requirements for conducting PEF studies according to this PEF Guide

Table 1: Key requirements for PEF studies in relation to the intended application

Intended applications		Goal & Scope definition	Screening exercise	Meet data quality requirements	Multifunctionality hierarchy	Choice of impact assessment methods	Classification & Characterisation	Normalisation & Weighting	Interpretation of PEF results	Reporting element requirements	Critical review (1 person)	Critical review panel (3 persons)	Requires PEFCR
In-house (claiming to be in line with the PEF Guide)		M	R	R	M	M	M	O	M	O	M	O	O
External	B2B / B2C without comparisons / comparative assertions	M	R	M	M	M	M	O	M	M	M	R	R
	B2B / B2C with comparisons / comparative assertions	M	R	M	M	M	M	O	M	M	/	M	M
"M" = mandatory; "R" = recommended (not mandatory); "O" = optional (not mandatory); "/" = not applicable													

REQUIREMENT FOR PEF STUDIES

A PEF study shall be based on a life-cycle approach.

1.2 How to Use this Guide

This Guide provides the information necessary to conduct a PEF study. The material in the PEF Guide is presented in a sequential manner, in the order of the methodological phases that shall be completed when calculating a PEF. Each section begins with a general description of the methodological phase, along with an overview of necessary considerations and supporting examples. “Requirements” specify the methodological norms that “shall / should” be satisfied in order to achieve a PEF-compliant study. These are positioned in text boxes with single line borders following the general description sections. “Tips” describe non-mandatory but recommended best practices. These are positioned in shaded text boxes, also with solid line borders. Where additional requirements for creating PEFCRs are specified, these are positioned in text boxes with double line borders at the end of each respective section.

1.3 Principles for Product Environmental Footprint Studies

To produce consistent, robust and reproducible PEF studies, a core suite of analytical principles shall be strictly adhered to. These principles provide overarching guidance in the application of the PEF method. They shall be considered with respect to each phase of PEF studies, from the definition of study goals and the scope of the research, through data collection, impact assessment, reporting and verification of study outcomes.

REQUIREMENT FOR PEF STUDIES

Users of this Guide shall observe the following principles in conducting a PEF study:

(1) Relevance

All methods used and data collected for the purpose of quantifying the PEF shall be as relevant to the study as possible.

(2) Completeness

Quantification of the PEF shall include all environmentally relevant material/energy flows and other environmental interventions as required for adherence to the defined system boundaries[26], the data requirements, and the impact assessment methods employed.

(3) Consistency

Strict conformity to this Guide shall be observed in all steps of the PEF study so as to ensure internal consistency and comparability with similar analyses.

(4) Accuracy

All reasonable efforts shall be taken to reduce uncertainties in product system[27] modelling and the reporting of results.

(5) Transparency

PEF information shall be disclosed in such a way as to provide intended users with the necessary basis for decision making, and for stakeholders to assess its robustness and reliability.

Principles for PEFCR

1. Relationship with the PEF Guide

In addition to the requirements of this PEF Guide, the methodological requirements set out in PEFCR shall also apply to PEF studies. Where the requirements of the PEFCR are more specific than those of the PEF Guide, such specific requirements shall be fulfilled.

2. Involvement of selected interested parties

The process of developing PEFCRs shall be open and transparent and shall include consultation with relevant stakeholders' parties. Reasonable efforts should be made to achieve a consensus throughout the

[26] System Boundary – Definition of aspects included or excluded from the study. For example, for a "cradle-to-grave" EF analysis should include all activities from the extraction of raw materials through the processing, distribution, storage, use, and disposal or recycling stages.

[27] Product system – collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product (ISO 14040:2006).

process (adapted from ISO 14020:2000, 4.9.1, Principle 8). The PEFCRs shall be peer reviewed.

3. Striving for comparability

The results of PEF studies that have been conducted in line with this PEF Guide and the relevant PEFCR document may be used to support the comparison of the environmental performance of products from the same product category on a life-cycle basis, as well as to support comparative assertions[28] (intended to be disclosed to the public). Therefore, comparability of the results is crucial. The information provided for this comparison shall be transparent in order to allow the user to understand the limitations of comparability inherent in the calculated result (adapted from ISO 14025).

1.4 Phases of a Product Environmental Footprint study

A number of phases shall be completed in carrying out a PEF study in line with this Guide - i.e. Goal Definition, Scope Definition, Resource Use and Emissions Profile, Environmental Footprint Impact Assessment, and Environmental Footprint Interpretation and Reporting - see Figure 1.

[28] Comparative assertions are environmental claims regarding the superiority or equivalence of one product versus a competing product that performs the same function. (ISO 14040:2006)

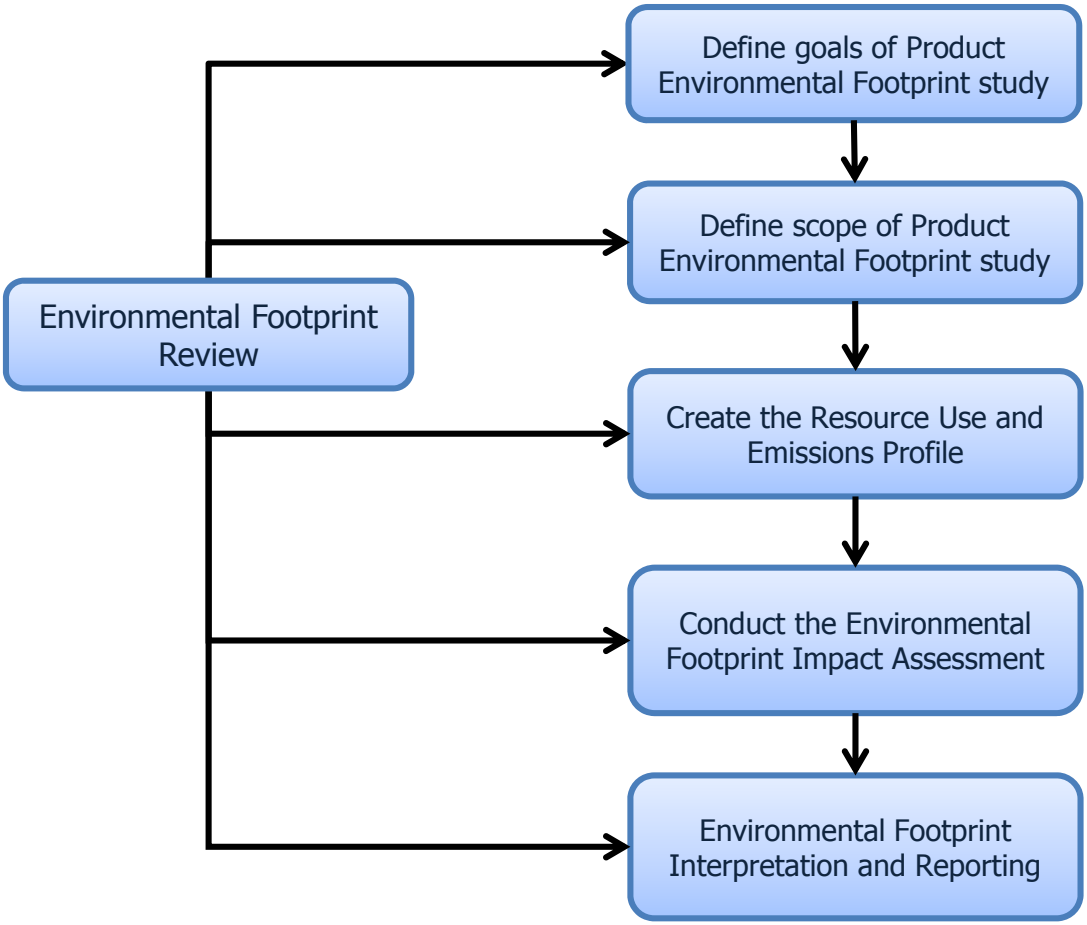

Figure 1: Phases of a Product Environmental Footprint study

2. Role of Product Environmental Footprint Category Rules (PEFCRs)

2.1 General

In addition to providing general guidance and requirements for PEF studies, this PEF Guide also specifies the requirements for developing PEFCRs. PEFCRs will play an important role in increasing the reproducibility, consistency (and therefore comparability between PEF calculations within the same product category[29] level), and relevance of PEF studies. PEFCRs will help direct the focus to the most important parameters of the PEF study, thus also reducing time, efforts and costs.

The objective is to ensure that PEFCRs are developed according to the PEF Guide and that they provide the specifications needed to achieve the comparability, increased reproducibility, consistency, relevance, focus and efficiency of PEF studies. PEFCRs should aim to focus PEF studies on those aspects and parameters which are most pertinent in determining the environmental performance of a given product type. A PEFCR can further specify requirements made in this PEF Guide and can add new requirements where the PEF Guide leaves several choices.

PEF studies may be carried out in the absence of PEFCRs if they are not intended for use in making comparative assertions intended to be disclosed to the public.

REQUIREMENT FOR PEF STUDIES

In absence of PEFCRs, the key areas that would be covered in PEFCRs (as listed in this PEF Guide) shall be specified, justified and explicitly reported in the PEF study.

2.2 Role of PEFCRs and relation with existing Product Category Rules (PCRs)

PEFCRs aim to provide detailed technical guidance on how to conduct a PEF study for a specific product category. PEFCRs shall provide further specification at the process and/or product level. In particular, PEFCRs will typically provide further specification and guidance in e.g.:

- Defining the goal and scope of the study;
- Defining relevant/irrelevant impact categories;
- Identifying appropriate system boundaries for the analysis;
- Identifying key parameters and life-cycle stages;
- Providing guidance on possible data sources;
- Completing the Resource Use and Emissions Profile phase;
- Providing further specification on how to solve multi-functionality[30] problems.

All of these aspects are explored in this PEF Guide.

[29] A product category is a group of products that can fulfil equivalent functions (ISO 14025:2006).

[30] If a process or facility provides more than one function, i.e. it delivers several goods and/or services ("co-products"), it is "multifunctional". In these situations, all inputs and emissions linked to the process must be partitioned between the product of interest and the other co-products in a principled manner (see section 6.10 and Annex V).

As defined in ISO 14025(2006), Product Category Rules (PCRs) [31] include sets of specific rules, guidelines and requirements that aim to develop "Type III environmental declarations" for any product category (i.e. goods and/or services providing equivalent functions). "Type III environmental declarations" are quantitative, LCA-based claims of the environmental aspects[32] of a certain good or service, e.g. quantitative information regarding potential environmental impacts.
For development and review of Product Category Rules (PCRs), ISO 14025(2006) describes the procedure and establishes requirements for comparability of different so-called "Type III environmental declarations". Type III environmental declarations may, for instance, be a potential application of a PEF study.

The guidelines on how to develop PEFCRs are based on the minimum content of a PCR document as required by ISO 14025. Following ISO 14025 for PCRs this includes, but is not limited to:

- Identification of the product category for which a PCR is to be developed, including a description of for example, the product's function(s), technical performance and use(s);
- Definition of the goal and scope for the Life Cycle Assessment (LCA)[33] of the product, according to the requirement of the ISO 14040 series in terms of, for example, functional unit, system boundary, data quality requirements[34];
- Description of the Life Cycle Inventory (LCI) analysis, with special focus on the data collection phase, calculation procedures, and allocation[35] rules;
- Choice of the EF impact category indicators to be included in the LCA;
- Description of any eventual predetermined parameter for the reporting of LCA data, for example, certain predetermined inventory data categories and/or EF impact category indicators;
- If not all life-cycle stages are included in the LCA, information/justification on which stages are not covered;
- Timespan of the validity of the PEFCR being developed.

If other PCRs are available from other schemes, these can be used as a basis for developing a PEFCR[36], in line with the requirements provided in this PEF Guide.

REQUIREMENT FOR DEVELOPING PEFCRs

PEFCRs should, to the extent possible and recognising the different application contexts, be in conformity with existing international Product Category Rule (PCR) guidance documents.

[31] Product Category Rules (PCR) are a set of specific rules, requirements and guidelines for developing Type III environmental declarations for one or more product categories (ISO 14025:2006).
[32] An environmental aspect is defined as an element of an organisation's activities or products that has or can have an impact on the environment.
[33] Life cycle assessment is the compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14040:2006)
[34] Data Quality refers to the **c**haracteristics of data that relate to their ability to satisfy stated requirements (ISO 14040:2006). Data quality covers various aspects, such as technological, geographical and time-related representativeness, as well as completeness and precision of the inventory data.
[35] Allocation is an approach to solving multi-functionality problems. It refers to "*partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems*" (ISO 14040:2006).
[36] In some cases, simple modifications/additions of existing PCRs may be sufficient.

2.3 PEFCR structure based on the Classification of Products by Activity (CPA)

The PEFCR document describes the type of information to be given about a product from a life-cycle perspective as well as how this information shall be generated. The Classification of Products by Activity (CPA) scheme (Figure 2) shall be used for coding and defining the information modules used to represent the product life cycle.

CPA product categories relate to activities as defined using NACE codes (i.e. by the Statistical classification of economic activities in the European Community). Each CPA product is assigned to one single NACE activity, hence the CPA structure is parallel to that of NACE at all levels.

NACE consists of a hierarchical structure as follows (NACE Rev. 2 2008[37], page 15):

1. Headings identified by an alphabetical code (sections);
2. Headings identified by a two-digit numerical code (divisions);
3. Headings identified by a three-digit numerical code (groups);
4. Headings identified by a four-digit numerical code (classes).

The International Standard Industrial Classification (ISIC) and NACE have the same code at the highest levels, but NACE is more detailed at the lower levels. As the NACE code in the context of this study applies to the sector level, at a minimum a 2-digit code (i.e. division level) shall be assigned[38]. This complies with the ISIC system.

An example of such an approach for a PEFCR document is given below for “Milk and milk-based products.” Here, the two-digit code (divisions) defines an industry-specific product group (e.g. division 10 - Food products) which has a number of individual products coded under it (e.g. group 10.51.11 - Processed liquid milk and cream) (Figure 2). Thus, the two-digit code, and sometimes the one digit code, may be used to define industry-specific information modules which, when combined, build up specific product life cycles in a horizontal structure. Each of these also provides an embedded vertical structure going from a general product group to more specific individual products.

[37] http://epp.eurostat.ec.europa.eu/portal/page/portal/product_details/publication?p_product_code=KS-RA-07-015

[38] The alphabetical section code does not appear in the digit code according to NACE and is therefore not of relevance here.

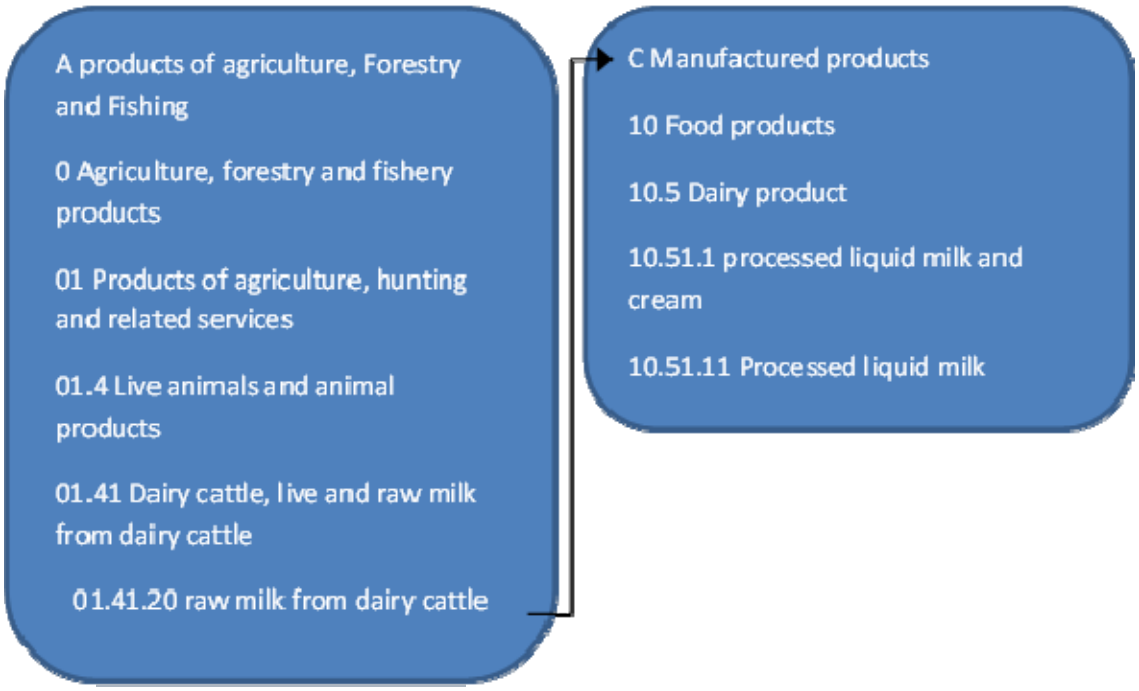

Figure 2: Outline of the principles of the CPA scheme

REQUIREMENT FOR DEVELOPING PEFCRs

PEFCRs shall be based at a minimum on a two-digit CPA code division (default option). However, PEFCRs may allow for (justified) deviations (e.g. allow for three-digits). For example, more than two-digits are necessary when addressing the complexity of the sector. Where multiple production routes for similar products are defined using alternative CPAs, the PEFCR shall accommodate all such CPAs.

3. Defining the Goal(s) of the Product Environmental Footprint Study

3.1 General

Goal definition is the first step of a PEF study, and sets the overall context for the study. The purpose of clearly defining goals is to ensure that the analytical aims, methods, results and intended applications are optimally aligned, and that a shared vision is in place to guide participants in the study. The decision to use the PEF Guide implies that some aspects of the goal definition will be decided a priori. Nonetheless, it is important to take the time to carefully consider and articulate goals in order to ensure the success of the PEF study.

In defining goals, it is important to identify the intended applications and the degree of analytical depth and rigour of the study. This should be reflected in the defined study limitations (scope definition phase). Quantitative studies in conformance with the analytical requirements specified in this PEF Guide will be necessary for analyses geared towards, for example, least cost environmental sourcing, product design, benchmarking and reporting. Combined approaches are also possible within one PEF study where only certain parts of the supply chain are subject to quantitative analysis and others to qualitative descriptions of potential environmental hotspots (for example, a quantitative cradle-to-gate[39] analysis combined with qualitative descriptions of gate-to-grave[40] environmental considerations or with quantitative analyses of the use and end-of-life stages for selected representative product types).

REQUIREMENT FOR PEF STUDIES

Goal definition for a PEF study shall include:

- Intended application(s);
- Reasons for carrying out the study and decision context;
- Target audience;
- Whether comparisons and/or comparative assertions[41] are to be disclosed to the public;
- Commissioner of the study;
- Review procedure (if applicable).

[39] An assessment of a partial product supply chain, from the extraction of raw materials (cradle) up to the manufacturer's "gate". The distribution, storage, use and end-of-life stages of the supply chain are omitted (see Glossary).

[40] An assessment that includes the raw material extraction, processing, distribution, storage, use, and disposal or recycling stages. All relevant inputs and outputs are considered for all of the stages of the life cycle (see Glossary).

[41] A comparative assertion is an environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function.

Example - Environmental Footprint of a T-shirt: goal definition

Aspects	Detail
Intended application(s):	Provide product information to customer
Reasons for carrying out the study and decision context:	Respond to a request from a customer
Comparisons intended to be disclosed to the public:	No, it will be publically available but it is not intended to be used for comparisons or comparative assertions.
Target audience:	External technical audience, business-to-business.
Review:	Independent external reviewer, Mr Y
Commissioner of the study:	G company limited

ADDITIONAL REQUIREMENT FOR DEVELOPMENT OF PEFCRs

The PEFCR shall specify the review requirements for a PEF study.

4. Defining the Scope of the Product Environmental Footprint Study

4.1 General

In defining the scope of the PEF study, the system to be evaluated and the associated analytical specifications are described in detail.

REQUIREMENT FOR PEF STUDIES

The scope definition for a PEF study shall be in line with the defined goals of the study and shall include (see subsequent sections for a more detailed description):

- Unit of analysis[42] and reference flow[43];
- System boundaries;
- Environmental Footprint impact categories;
- Assumptions/Limitations.

4.2 Unit of analysis and reference flow

Users of the PEF Guide are required to define the unit of analysis and reference flow for the PEF study. The unit of analysis qualitatively and quantitatively describes the function(s) and duration of the product.

REQUIREMENT FOR PEF STUDIES

The unit of analysis for a PEF study shall be defined according to the following aspects:

- The function(s)/service(s) provided: “what”;
- The extent of the function or service: “how much”;
- The expected level of quality: “how well”;
- The duration/life time of the product: “how long”;
- The NACE code(s).

ADDITIONAL REQUIREMENT FOR DEVELOPMENT OF PEFCRs

PEFCRs shall specify the unit(s) of analysis.

[42] The term “unit of analysis” is used throughout this Guide in place of the term “functional unit” used in ISO 14044.

[43] The reference flow is a measure of the outputs from processes in a given product system required to fulfil the function expressed by the unit of analysis (based on ISO 14040:2006).

Example:

Guide/Requirement: Define functional unit

Names and quantifies the qualitative and quantitative aspects of the function(s) of product along the questions "what", "how much", "how well", and "for how long".

Example define functional unit,
Function unit of T shirt:
(WHAT) T shirt (average for size S, M, L) made from polyester,
(HOW MUCH) One T shirt,
(HOW WELL) Wear One time per week and use washing machine at 30 degree for cleaning
(HOW LONG) for 5 years.

Note:

Some interim products may have more than one function. It may be necessary to identify and choose among these functions.

The reference flow is the amount of product needed in order to provide the defined function. All other input[44] and output[45] flows in the analysis quantitatively relate to it. The reference flow can be expressed in direct relation to the unit of analysis or in a more product-oriented way.

REQUIREMENT FOR PEF STUDIES

An appropriate reference flow shall be determined in relation to the unit of analysis. The quantitative input and output data collected in support of the analysis shall be calculated in relation to this flow.

Example:

Reference flow: 160 grammes of polyester

4.3 System boundaries for Product Environmental Footprint Studies

The system boundaries define which parts of the product life cycle and which associated processes belong to the analysed system (i.e. are required for carrying out its function as defined by the unit of analysis). Therefore, the system boundary must be clearly defined for the product system to be evaluated.

[44] Input – product, material or energy flow that enters a unit process. Products and materials include raw materials, intermediate products and co-products (ISO 14040:2006).
[45] Output – product, material or energy flow that leaves a unit process. Products and materials include raw materials, intermediate products, co-products and releases (ISO 14040:2006).

System boundary diagram (recommended)

A system boundary diagram, or a flow diagram, is a schematic representation of the analysed system. It details which parts of the product life cycle are included or excluded from the analysis. A system boundary diagram can be a useful tool in defining the system boundary and organising subsequent data collection activities.

TIP: It is not mandatory to prepare a system boundary diagram, but it is highly recommended. The system boundary diagram will help to define and structure the analysis.

REQUIREMENT FOR PEF STUDIES

The system boundary shall be defined following general supply-chain logic, including all stages from raw material[46] extraction through processing, production, distribution, storage, use stage and end-of-life treatment of the product (i.e. cradle-to-grave[47]), as appropriate to the intended application of the study. The system boundaries shall include all processes linked to the product supply chain relative to the unit of analysis.

The processes included in the system boundaries shall be divided into foreground processes (i.e. core processes in the product life cycle for which direct access to information is available[48]) and background processes (i.e. those processes in the product life cycle for which no direct access to information is possible[49]).

A system boundary diagram should be included in the scope definition.

ADDITIONAL REQUIREMENTS FOR DEVELOPMENT OF PEFCRs

The PEFCR shall specify the system boundaries for product category PEF studies, including specification of relevant life cycle stages and processes that should be generally assigned to each stage (including temporal, geographical, and technological specifications). Any deviation from the default cradle-to-grave approach shall be explicitly specified and justified, e.g. exclusion of the unknown use-stage or end-of-life of intermediate products[50].

The PEFCR shall specify downstream[51] scenarios so as to ensure comparability and consistency among PEF studies.

[46] Raw material is a primary or secondary material that is used to produce a product (ISO 14040:2006).

[47] Cradle-to-Grave - An assessment that includes the raw material extraction, processing, distribution, storage, use, and disposal or recycling stages. All relevant inputs and outputs are considered for all of the stages of the life cycle.

[48] For example, the producer's site and other processes operated by the producer or its contractors such as goods transport, head-office services, etc.

[49] For example, e.g. most of the upstream life cycle processes – such as infrastructures, buildings - and generally all processes further downstream

[50] Intermediate product – output form a unit process that is input to other unit processes that require further transformation within the system (ISO 14040:2006)

[51] Downstream – occurring along the supply chain of goods/services after the point of production.

Offsets

The term "offset" is frequently used with reference to third-party greenhouse gas mitigation activities, e.g. regulated schemes in the framework of the Kyoto Protocol (CDM – Clean Development Mechanism, JI – Joint Implementation, ETS - Emissions Trading Schemes), or voluntary schemes. Offsets are discrete greenhouse gas (GHG) reductions used to compensate for (i.e., offset) GHG emissions elsewhere, for example to meet a voluntary or mandatory GHG target or cap. Offsets are calculated relative to a baseline that represents a hypothetical scenario for what emissions would have been in the absence of the mitigation project that generates the offsets. Examples of offset emissions are carbon off-setting by the Clean Development Mechanism, carbon credits, and other system-external off-sets.

REQUIREMENT FOR PEF STUDIES

Offsets shall not be included in the PEF study, but may be reported separately as "Additional Environmental Information."

4.4 Selecting Environmental Footprint Impact Categories and Assessment Methods

Environmental footprint (EF) impact categories[52] refer to specific categories of impacts considered in a PEF study. These are generally related to resource use, emissions of environmentally damaging substances (e.g., greenhouse gases and toxic chemicals), which may as well affect human health. EF impact assessment methods use models for quantifying the causal relationships between the material/energy inputs and emissions associated with the product life cycle (inventoried in the Resource Use and Emissions Profile) and each EF impact category[53] considered. Each category hence refers to a certain stand-alone EF impact assessment model.

The purpose of EF impact assessment[54] is to group and aggregate the inventoried Resource Use and Emissions Profile data according to the respective contributions to each EF impact category. This subsequently provides the necessary basis for interpretation of the EF results relative to the goals of the PEF study (for example, identification of supply chain "hotspots" and "options" for improvement). The selection of EF impact categories should therefore be comprehensive in the sense that they cover all relevant environmental issues related to the product supply chain of interest.

Table 2 provides a default list of EF impact categories and related assessment methods to be used.[55] Further instructions on how to calculate these impacts are described in Chapter 6.

[52] The term "EF impact category" is used throughout this Guide in place of the term "impact category" used in ISO 14044.

[53] The term "EF impact category indicator" is used throughout this Guide instead of the term "impact category indicator" used in ISO 14044:2006.

[54] The term "EF impact assessment" is used throughout this Guide instead of the term "life cycle impact assessment" used in ISO 14044:2006. It is the phase of the PEF analysis which aims to understand and evaluate the magnitude and significance of the potential environmental impacts of a product throughout its life cycle (based on ISO 14044:2006). The EF impact assessment methods provide impact characterisation factors for elementary flows to aggregate the impact to a limited number of midpoint and/or damage indicators.

[55] For more information on environmental impact categories and assessment methods, reference is made to the ILCD Handbook "Framework and requirements for LCIA models and indicators", "Analysis of existing Environmental Assessment methodologies for use in LCA" and "Recommendation for life cycle impact assessment in the European context". These are available online at http://lct.jrc.ec.europa.eu/

Table 2: Default EF impact categories (with respective EF impact category indicators) and EF impact assessment models for PEF studies

EF Impact Category	EF Impact Assessment Model	EF Impact Category indicators	Source
Climate Change	Bern model - Global Warming Potentials (GWP) over a 100 year time horizon.	kg CO_2 equivalent	Intergovernmental Panel on Climate Change, 2007
Ozone Depletion	EDIP model based on the ODPs of the World Meteorological Organization (WMO) over an infinite time horizon.	kg CFC-11 equivalent	WMO, 1999
Ecotoxicity for aquatic fresh water	USEtox model	CTUe (Comparative Toxic Unit for ecosystems)	Rosenbaum et al., 2008
Human Toxicity - cancer effects	USEtox model	CTUh (Comparative Toxic Unit for humans)	Rosenbaum et al., 2008
Human Toxicity – non-cancer effects	USEtox model	CTUh (Comparative Toxic Unit for humans)	Rosenbaum et al., 2008
Particulate Matter/Respiratory Inorganics	RiskPoll model	kg PM2.5 equivalent	Humbert, 2009
Ionising Radiation – human health effects	Human Health effect model	kg U^{235} equivalent (to air)	Dreicer et al., 1995
Photochemical Ozone Formation	LOTOS-EUROS model	kg NMVOC equivalent	Van Zelm et al., 2008 as applied in ReCiPe
Acidification	Accumulated Exceedance model	mol H+ eq	Seppälä et al.,2006; Posch et al., 2008
Eutrophication – terrestrial	Accumulated Exceedance model	mol N eq	Seppälä et al.,2006; Posch et al., 2008
Eutrophication – aquatic	EUTREND model	fresh water: kg P equivalent marine: kg N equivalent	Struijs et al., 2009 as implemented in ReCiPe
Resource Depletion – water	Swiss Ecoscarcity model	m^3 water use related to local scarcity of water	Frischknecht et al., 2008
Resource Depletion – mineral, fossil	CML2002 model	kg antimony (Sb) equivalent	van Oers et al., 2002
Land Transformation	Soil Organic Matter (SOM) model	Kg (deficit)	Milà i Canals et al., 2007

* CFC-11 = Trichlorofluoromethane, also called freon-11 or R-11, is a chlorofluorocarbon.

** PM2.5 = Particulate Matter with a diameter of 2.5 µm or less.

*** NMVOC = Non-Methane Volatile Organic Compounds

**** Sb = Antimony

Depending on the product system and intended application, users of this PEF Guide may elect to narrow the suite of EF impact categories considered. Such exclusions should be supported by appropriate documents, such as (non-exhaustive list):

- International consensus process;
- Independent external review;
- Multi-stakeholder process;
- LCA studies which have been peer reviewed;
- Screening step (see section 5.2).

REQUIREMENT FOR PEF STUDIES

The selection of EF impact categories should be comprehensive in the sense that they cover all relevant environmental issues related to the product supply chain of interest. For a PEF study, all of the specified default EF impact categories and associated specified EF impact assessment models shall be applied. Any exclusion shall be explicitly documented, justified, reported in the PEF report and supported by appropriate documents.

The influence of any exclusion on the final results, especially related to limitations in terms of comparability with other PEF studies, shall be discussed in the interpretation phase and reported. Such exclusions are subject to review.

ADDITIONAL REQUIREMENT FOR DEVELOPMENT OF PEFCRs

PEFCRs shall specify and justify any exclusion of the default EF impact categories, especially those related to the aspects of comparability.

4.5 Selecting additional environmental information to be included in the PEF

Relevant potential environmental impacts of a product may go beyond the widely accepted life-cycle-based EF impact assessment models. It is important to consider these environmental impacts whenever feasible. For example, biodiversity impacts due to land use changes may occur in association with a specific site or activity. This may require the application of additional EF impact categories that are not included in the default list provided in this PEF Guide, or even additional qualitative descriptions where impacts cannot be linked to the product supply chain in a quantitative manner. Such additional methods should be viewed as complementary to the default list of EF impact categories.

Some products might be produced in companies which are located close to the sea. Their emissions might therefore directly impact marine water instead of to fresh water. Because the default set of EF impact categories only include ecotoxicity resulting from emissions to fresh water, it is important to also consider emissions that are made directly into marine water. These shall be included at elementary level because no impact assessment model is currently available for such emissions.

Additional environmental information may include (non-exhaustive list):

(a) Bill-of-materials data;
(b) Disassemblability, recyclability, recoverability, reusability information, resource efficiency;
(c) Information on the use of hazardous substances;
(d) Information on the disposal of hazardous/non-hazardous waste;
(e) Information on energy consumption;
(f) Information on local/site-specific impacts, e.g. local impacts on acidification, eutrophication and biodiversity;
Other relevant environmental information on the activities and/or sites involved, as well as on the product output.

REQUIREMENT FOR PEF STUDIES

If the default set of EF impact categories or the default impact assessment models do not properly cover the potential environmental impacts of the product being evaluated, all related relevant (qualitative/quantitative) environmental aspects shall be additionally included under "additional environmental information". These shall, however, not substitute the mandatory assessment models of the default EF impact categories. The supporting models of these additional categories shall be clearly referenced and documented with the corresponding indicators.

Additional environmental information shall be:

- Based on information that is substantiated and has been reviewed or verified in accordance with the requirements of ISO 14020 and Clause 5 of ISO 14021:1999;
- Specific, accurate and not misleading;
- Relevant to the particular product category.

Emissions made directly into marine water shall be included in the additional environmental information (at inventory level).

If additional environmental information is used to support the interpretation phase of a PEF study, then all data needed to produce such information shall meet the same quality requirements established for the data used to calculate the PEF results (see section 5.6[56]).

Additional environmental information shall only be related to environmental issues. Information and instructions, e.g. product safety sheets that are not related to the environmental performance of the product shall not be part of a PEF. Similarly, information related to legal requirements shall not be included.

[56] Data Quality - Characteristics of data that relate to their ability to satisfy stated requirements (ISO 14040:2006). Data quality covers various aspects, such as technological, geographical and time-related representativeness, as well as completeness and precision of the inventory data.

ADDITIONAL REQUIREMENT FOR DEVELOPMENT OF PEFCRs

The PEFCR shall specify and justify additional environmental information that is to be included in the PEF study. Such additional information shall be reported separately from the life-cycle-based PEF results, with all methods and assumptions clearly documented. Additional environmental information may be quantitative and/or qualitative.

Additional environmental information may include (non-exhaustive list):

- Other relevant environmental impacts for the product category;
- Other relevant technical parameters that may be used to assess the product under study and allow for comparisons with other products of the overall product efficiency. These technical parameters may refer to, for example, the use of renewable versus non-renewable energy, the use of renewable versus non-renewable fuels, the use of secondary materials, the use of fresh water resources, or the disposal of hazardous versus non-hazardous waste types;
- Other relevant approaches for conducting characterisation[57] of the flows from the Resource Use and Emissions Profile, when characterisation factors[58] (CFs) in the default method are not available for certain flows (e.g. groups of chemicals);
- Environmental indicators or product responsibility indicators (as per the Global Reporting Initiative (GRI));
- Life-cycle energy consumption by primary energy source, separately accounting for “renewable” energy use;
- Direct energy consumption by primary energy source, separately accounting for “renewable” energy use for facility gate;
- For gate-to-gate phases, number of IUCN Red List species and national conservation list species with habitats in areas affected by operations, by level of extinction risk;
- Description of significant impacts of activities, products, and services on biodiversity in protected areas and in areas of high biodiversity value outside protected areas;
- Total weight of waste by type and disposal method;
- Weight of transported, imported, exported, or treated waste deemed hazardous under the terms of the Basel Convention Annexes I, II, III, and VIII, and percentage of transported waste shipped internationally.

[57] Characterisation refers to the calculation of the magnitude of the contribution of each classified input/output to their respective EF impact categories, and aggregation of contributions within each category. This requires a linear multiplication of the inventory data with *characterisation factors* for each substance and EF impact category of concern. For example, with respect to the EF impact category “climate change”, CO_2 is chosen as reference substance and the reference unit is kg CO_2-equivalents.

[58] A characterisation factor is a factor derived from a characterisation model which is applied to convert an assigned Resource Use and Emissions Profile result to the common unit of the EF impact category indicator (based on ISO 14040:2006).

4.6 Assumptions/limitations

In PEF studies, several limitations to carrying out the analysis may arise and therefore assumptions need to be made. For example, generic data[59] may not completely represent the reality of the product analysed and may be adapted for better representation.

REQUIREMENT FOR PEF STUDIES

All limitations and assumptions shall be transparently reported.

ADDITIONAL REQUIREMENTS FOR PEFCRs

The PEFCR shall report product-category-specific limitations and define the assumptions necessary to overcome the limitations.

[59] Generic data is data that is not directly collected, measured, or estimated, but rather sourced from a third-party life-cycle inventory database or other source that complies with the data quality requirements of the Organisation Environmental Footprint method.

5. Compiling and Recording the Resource Use and Emissions Profile

5.1 General

An inventory (profile) of all material/energy resource inputs/outputs and emissions into air, water and soil for the product supply chain shall be compiled as a basis for modelling the PEF. This is called the Resource Use and Emissions Profile[60].

Ideally, the model of the product supply chain would be constructed using facility- or product-specific data (i.e. modelling the exact life cycle depicting the supply chain, use, and end-of-life stages as appropriate). In practice, and as a general rule, directly collected, facility-specific inventory data should be used wherever possible. For processes where the company does not have direct access to specific data (i.e. background processes), generic data[61] will typically be used. However, it is good practice to access data collected directly from suppliers for the most relevant products supplied by them when possible, unless generic data are more representative or appropriate.

The resource use and emissions profile shall adopt the following classifications[62] of the flows included:

- **Elementary flows,** which are (ISO 14040:2006, 3.12) "*material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation."* Elementary flows are, for example, resources extracted from nature or emissions into air, water, soil that are directly linked to the characterisation factors of the EF impact categories;
- **Non-elementary (or complex) flows**, which are all the remaining inputs (e.g. electricity, materials, transport processes) and outputs (e.g. waste, by-products) in a system that require further modelling efforts to be transformed into elementary flows.

All non-elementary flows in the Resource Use and Emissions Profile shall be transformed into elementary flows. For example, waste flows shall not only be reported as kg of household waste or hazardous waste, but shall also include the emissions into water, air and soil due to the treatment of the solid waste. This is necessary for the comparability of PEF studies. The compilation of the resource use and emissions profile is therefore completed when all flows are expressed as elementary flows.

TIP: Documenting the data collection process is useful for improving the data quality over time, preparing for critical review[63], and revising future product inventories to reflect changes in production practices. To ensure that all of the relevant information is documented, establishing a data management plan early in the inventory process may be helpful (see Annex II).

[60] The term "Resource Use and Emissions Profile" is used throughout this Guide in place of the term "life cycle inventory" used in ISO 14044.

[61] Generic data refers to data that is not directly collected, measured, or estimated, but rather sourced from a third-party life cycle inventory database or other source that complies with the data quality requirements of the PEF method.

[62] Classification is defined as assigning the material/energy inputs and outputs tabulated in the Resource and Emissions Profile to EF impact categories according to each substance's potential to contribute to each of the EF impact categories considered.

[63] A critical review is a process intended to ensure consistency between a PEF study and the principles and requirements of this PEF Guide and PEFCRs (if available) (based on ISO 14040:2006).

Compiling the resource use and emissions profile in a PEF study may be completed following a 2-step procedure, as explained in Figure 3. The first step is not mandatory, but is highly recommended.

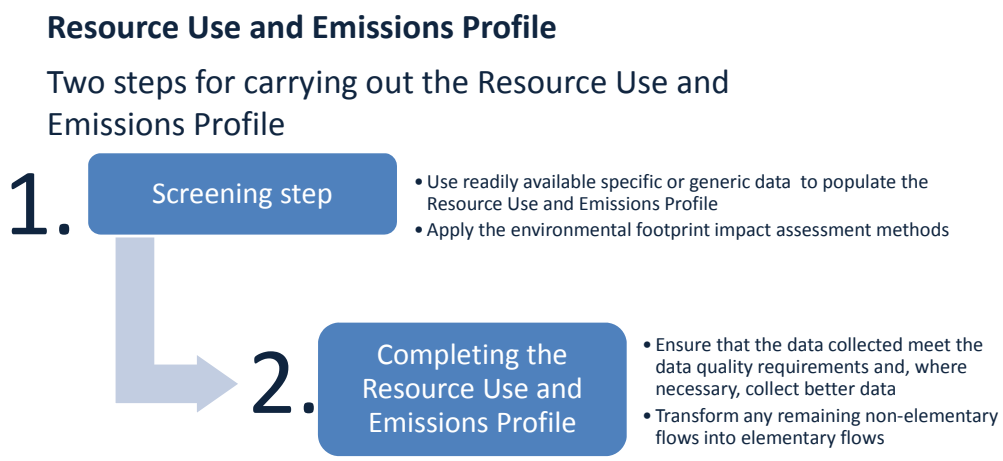

Figure 3: Two-step procedure to compile the Resource Use and Emissions Profile

REQUIREMENT FOR PEF STUDIES

All resource use and emissions associated with the life-cycle stages included in the defined system boundaries shall be included in the Resource Use and Emissions Profile. The flows shall be grouped into "elementary flows" and "non-elementary (i.e. complex) flows". All non-elementary flows in the Resource Use and Emissions Profile shall then be transformed into elementary flows.

5.2 Screening step (recommended)

An initial "screening-level" Resource Use and Emissions Profile, referred to as the screening step, is highly recommended because it helps focussing data collection activities and data quality priorities for the actual Resource Use and Emissions Profile.

REQUIREMENT FOR PEF STUDIES

If a screening step is conducted (highly recommended), readily available specific and/or generic data shall be used fulfilling the data quality requirements as defined in Section 5.6. All processes and activities to be considered in the Resource Use and Emissions Profile shall be included in the screening step. Any exclusion of supply-chain stages shall be explicitly justified and submitted to the review process, and their influence on the final results shall be discussed.

For supply-chain stages for which a quantitative EF impact assessment is not intended, the screening step shall refer to existing literature and other sources in order to develop qualitative descriptions of potentially environmentally significant processes. Such qualitative descriptions shall be included in the additional environmental information.

ADDITIONAL REQUIREMENT FOR DEVELOPMENT OF PEFCRs

The PEFCR shall specify processes to be included, as well as associated data quality and review requirements, which may exceed those of this PEF Guide. It shall also specify for which processes specific data are required, and for which the use of generic data is either permissible or required.

5.3 Data management plan (optional)

A data management plan may be a valuable tool for managing data and for tracking the process of compiling the product Resource Use and Emissions Profile.

The data management plan can include:

- A description of data collection procedures;
- Data sources;
- Calculation methodologies;
- Data transmission, storage and backup procedures;
- Quality control and review procedures for data collection, input and handling activities, data documentation and emissions calculations.

For additional guidance on possible approaches to formulating a data management plan, see Annex II.

5.4 Resource Use and Emissions Profile Data

REQUIREMENT FOR PEF STUDIES

All resource use and emissions associated with the life-cycle stages included in the defined system boundaries shall be included in the Resource Use and Emissions Profile.

The following elements shall be considered for inclusion in the Resource Use and Emissions Profile:

- Raw material acquisition and pre-processing;
- Capital goods: linear depreciation shall be used;
- Production;
- Product distribution and storage;
- Use stage;
- Logistics;
- End-of-life.

ADDITIONAL REQUIREMENT FOR DEVELOPMENT OF PEFCRs

The PEFCRs should provide one or more examples for compiling the Resource Use and Emissions Profile, including specifications with respect to:

- Substance lists for activities/processes included;
- Units;
- Nomenclature for elementary flows.

These may apply to one or more supply-chain stages, processes, or activities, for the purpose of ensuring standardised data collection and reporting. The PEFCR may specify more stringent data requirements for key upstream, gate-to-gate[64] or downstream stages than those defined in this PEF Guide.

For modelling processes/activities within the core module (i.e. gate-to-gate stage), the PEFCR shall also specify:

- Processes/activities included;
- Specifications for compiling data for key processes, including averaging data across facilities;
- Any site-specific data required for reporting as "additional environmental information";
- Specific data quality requirements, e.g. for measuring specific activity data.

If the PEFCR also requires deviations from the default cradle-to-grave system boundary (e.g. PEFCR prescribes using the cradle-to-gate boundary), the PEFCR shall specify how material/energy balances in the Resource Use and Emissions Profile shall be accounted for.

5.4.1 Raw Material Acquisition and Pre-processing (Cradle-to- Gate)[65]

The raw material acquisition and pre-processing stage starts when resources are extracted from nature and ends when the product components enter (through the gate of) the product's production facility. Processes that may occur in this stage include:

- Mining and extraction of resources;
- Pre-processing of all material inputs to the studied product, such as:
    - Forming metals into ingots;
    - Cleaning coal;
- Conversion of recycled material;
- Photosynthesis for biogenic materials;
- Cultivation and harvesting of trees or crops;
- Transportation within and between extraction and pre-processing facilities, and to the production facility.

5.4.2 Capital goods

Examples of capital goods that shall be included are:

- Machinery used in production processes;
- Buildings;
- Office equipment;

[64] Gate to Gate – A partial assessment looking only at the processes within a specific organisation or site.

[65] This section builds upon the Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Standard, 2011 – Chapter 7.3.1

- Transport vehicles;
- Transportation infrastructure.

Linear depreciation shall be used for the capital goods.

5.4.3 Production[68]

The production stage begins when the product components enter the production site and ends when the finished product leaves the production facility. Examples of production-related activities include:

- Chemical processing;
- Manufacturing;
- Transport of semi-finished products between manufacturing processes;
- Assembly of material components;
- Packaging;
- Treatment of waste;
- Employee transport (if relevant);
- Business travel (if relevant).

5.4.4 Product Distribution and Storage[68]

Products are distributed to users and may be stored at various points along the supply chain. Examples of processes related to distribution and storage that shall be included are (non-exhaustive list):

- Energy inputs for warehouse lighting and heating;
- Use of refrigerants in warehouses and transport vehicles;
- Fuel use by vehicles.

5.4.5 Use stage[68]

The use stage begins when the consumer or end user takes possession of the product and ends when the used product is discarded for transport to a recycling or waste treatment facility. Examples of use-stage processes to be included are (non-exhaustive list):

- Use/consumption patterns, location, time (day/night, summer/winter, week/weekend), and assumed use stage lifespan of products;
- Transportation to the location of use;
- Refrigeration at the location of use;
- Preparation for use (e.g. microwaving);
- Resource consumption during use (e.g. detergent, energy and water use for washing machine);
- Repair and maintenance of the product during the use stage.

The use scenario also needs to reflect whether or not the use of the analysed products might lead to changes in the systems in which they are used. Energy-using products, for example, might affect the energy needed for heating/cooling in a building, or the weight of a car battery might affect the fuel consumption of the car. The following sources of technical information on the use scenario should be taken into account (non-exhaustive list):

- Published international standards that specify guidance and requirements for the development of scenarios for and the service life of the use stage of the product being assessed;
- Published national guidelines for the development of scenarios for and the service life of the use stage of the product being assessed;

- Published industry guidelines for the development of scenarios for and service life of the use stage of the product being assessed;
- Market surveys or other market data.

NOTE: The manufacturer's recommended method to be applied in the use stage (e.g. cooking in an oven at a specified temperature for a specified time) might provide a basis for determining the use stage of a product. The actual usage pattern may, however, differ from those recommended and should be used if this information is available.

REQUIREMENT FOR PEF STUDIES

Where no method for determining the use stage of products has been established in accordance with the techniques specified in this PEF Guide, the approach taken in determining the use stage of products shall be established by the organisation carrying out the study. The actual usage pattern may, however, differ from those recommended and should be used if this information is available. Relevant influences on other systems due to the use of the products shall be included.

Documentation of methods and assumptions shall be provided. All relevant assumptions for the use stage shall be documented.

ADDITIONAL REQUIREMENT FOR DEVELOPMENT OF PEFCRs

The PEFCRs shall specify:

- The use stage scenarios to be included in the study, if any;
- The timespan to be considered for the use stage.

5.4.6 Modelling logistics for the analysed product

Important parameters that should, or shall (case-specific, see below) be taken into account when modelling transport include:

1. **Transport type:** The type of transport, e.g. by land (truck, rail, pipe), by water (boat, ferry, barge), or air (airplane), shall be taken into account;
2. **Vehicle type & fuel consumption:** The type of vehicle shall be taken into account by transport type, as well as the fuel consumption when fully loaded and empty. An adjustment shall be applied to the consumption of a fully-loaded vehicle according to loading rate[66];
3. **Loading rate:** Environmental impacts are directly linked to the actual loading rate, which shall therefore be considered;
4. **Number of empty returns:** the number of empty returns (i.e. the ratio of the distance travelled to collect the next load after unloading the product to the distance travelled to transport the product), when applicable and relevant, shall be taken into account. The kilometres travelled by the empty vehicle shall be allocated to the product. Specific values shall be developed by country and by type of transported product;

[66] The loading rate is the ratio or capacity (e.g. mass or volume) that a vehicle carries per trip.

5. **Transport distance**: Transport distances shall be documented, applying average transport distances specific to the context being considered;

6. **Allocation of impacts from transport:** A fraction of the impacts from transportation activities shall be allocated to the unit of analysis (to the considered product) based on the load-limiting factor. The following modelling principles should be considered:
   - Goods transport: time or distance AND mass or volume (or in specific cases: pieces/pallets) of the transported good:

     a) If the maximum authorised weight is reached before the vehicle has reached its maximum physical load: at 100% of its volume (high density products), then allocation shall be based on the mass of transported products;

     b) If the vehicle is loaded at 100% of the volume but it does not reach the authorised maximum weight (low density products), then allocation shall be based on the volume of the transported products;
   - Personal transport: time or distance;
   - Staff business travel: time, distance or economic value;

7. **Fuel production:** Fuel production shall be taken into account. Default values for fuel production can be found, for example, in the European Reference Life Cycle Database (ELCD)[67];

8. **Infrastructure:** the transport infrastructure, that of road, rail and water, should be taken into account;

9. **Resources and tools:** the amount and type of additional resources and tools needed for logistic operations such as cranes and transporters should be taken into account.

REQUIREMENT FOR PEF STUDIES

Transport parameters that shall be taken into account are: transport type, vehicle type and fuel consumption, loading rate, number of empty returns (when relevant), transport distance, allocation for goods transport based on load-limiting factor (i.e. mass for high-density products and volume for low-density products) and fuel production.

Transport parameters that should be taken into account are: transport infrastructure, additional resources and tools such as cranes and transporters, allocation for personal transport based on time or distance, allocation for staff business travel based on time, distance or economic value.

The impacts due to transport shall be expressed in the default reference units, i.e. tkm for goods and person-km for passenger transport. Any deviation from these default reference units shall be justified and reported.

The environmental impact due to transport shall be calculated by multiplying the impact per reference unit for each of the vehicle types by

a) for goods: the distance and load;

b) for persons: the distance and number of persons based on the defined transport scenarios.

[67] For more information, please refer to: http://lct.jrc.ec.europa.eu/assessment/data

ADDITIONAL REQUIREMENT FOR DEVELOPMENT OF PEFCRs

The PEFCRs shall specify transport, distribution and storage scenarios to be included in the study, if any.

5.4.7 End-of-Life[68]

The end-of-life stage begins when the used product is discarded by the user and ends when the product is returned to nature as a waste product or enters another product's life cycle (i.e. as a recycled input). Examples of end-of-life processes that shall be included in the PEF study include:

- Collection and transport of end-of-life products and packages;
- Dismantling of components;
- Shredding and sorting;
- Conversion into recycled material;
- Composting or other organic-waste-treatment methods;
- Littering;
- Incineration and disposal of bottom ash;
- Landfilling and landfill operation and maintenance;
- Transport required to all end-of-life treatment facilities.

As it is often not known exactly what will happen at the end-of-life of a product, end-of-life scenarios shall be defined.

REQUIREMENT FOR PEF STUDIES

Waste flows arising from processes included in the system boundaries shall be modelled to the level of elementary flows.

ADDITIONAL REQUIREMENT FOR DEVELOPMENT OF PEFCRs

The end-of-life scenarios, if any, shall be defined in the PEFCRs. These scenarios shall be based on current (year of analysis) practice, technology and data.

5.4.8 Accounting for Electricity Use (including Use of Renewable Energy)

Electricity from the grid consumed upstream or within the defined PEF boundary shall be modelled as precisely as possible giving preference to supplier-specific data. If (part of) the electricity is renewable it is important that no double counting occurs. Therefore the supplier shall guarantee that the renewable electricity supplied to the organisation to produce the product is effectively the supplied energy and that it is not put into the grid to be used by other consumers (e.g., Guarantee of Origin for production of renewable electricity[69]).

[68] This section builds upon the Greenhouse Gas Protocol's Product Life Cycle Accounting and Reporting Standard, 2011 – Chapter 7.3.1

[69] European Union 2009: DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND COUNCIL of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, Official Journal of the European Union.

REQUIREMENT FOR PEF STUDIES

For electricity from the grid consumed upstream or within the defined PEF boundary, supplier-specific data shall be used if available. If supplier-specific data is not available, country-specific consumption-mix data shall be used of the country in which the life cycle stages occur. For electricity consumed during the use stage of products, the energy mix shall reflect ratios of sales between countries or regions. Where such data are not available, the average EU consumption mix, or otherwise most representative mix, shall be used.

It shall be guaranteed that the renewable electricity (and associated impacts) from the grid consumed upstream or within the defined PEF boundary is not double counted. A statement of the supplier shall be included as an annex to the PEF report, guaranteeing that the electricity supplied is effectively generated using renewable sources and is not sold to any other organisation.

5.4.9 Additional considerations for compiling the resource use and emissions profile

Biogenic carbon removals and emissions

Carbon is removed from the atmosphere, for example, as part of the process of growing wood (characterisation factor[70] of -1 CO_2 eq. for global warming), while it is released during the burning of wood (characterisation factor of +1 CO_2 eq. for global warming).

REQUIREMENT FOR PEF STUDIES

Removals and emissions of biogenic carbon sources shall be kept separated in the Resource Use and Emissions Profile. [71]

Direct Land Use Change (impact for climate change): the impact of land use change on climate change results basically from a change in carbon stocks in land. Direct Land Use Change occurs as the results of a transformation from one land use type into another, which takes place in a unique land cover, possibly incurring changes in the carbon stock of that specific land, but not leading to a change in another system. For details, see Annex VI.

Indirect Land Use Change (impact for climate change): the impact of land use change on climate change results basically from a change in carbon stocks in land. Indirect Land Use Change occurs when a certain change in land use induces changes outside the system boundaries, i.e. in other land use types.

REQUIREMENT FOR PEF STUDIES

Greenhouse gas emissions that occur as a result of direct land use change shall be allocated to goods/services for 20 years after the land use change occurs using the IPCC default values table. For details, see Annex VI. Greenhouse gas emissions that occur as a result of indirect land use change shall not be included.

[70] A characterisation factor is a factor derived from a characterisation model which is applied to convert an assigned Resource Use and Emissions Profile result to the common unit of the EF category indicator (based on ISO 14040:2006).

[71] A separate inventory of emissions/removals of biogenic carbon sources implies that the following characterisation factors (see section 6.1.2) shall be assigned for the environmental footprint impact category Climate Change: "-1" for removals of biogenic carbon dioxide; "+1" for emissions of biogenic carbon dioxide; "+25" for methane emissions.

Accounting for Renewable Energy Generation

Within the assessed system boundary, energy may be produced from renewable sources. If renewable energy is produced in excess of the amount consumed within the defined system boundary and it is provided to, for example, the electricity grid, this may only be credited to the product assessed provided that the credit has not already been taken into account in other schemes. Documentation (e.g. Guarantee of Origin for production of renewable electricity[72]) is required to explain whether or not the credit is considered in the calculation.

REQUIREMENT FOR PEF STUDIES

Credits associated with renewable energy generated by the system boundary shall be calculated with respect to the corrected (i.e. by subtracting the externally provided amount of renewable energy) average, country-level consumption mix of the country to which the energy is provided. Where such data is not available, the corrected average EU consumption mix, or otherwise most representative mix shall be used. If no data are available on the calculation of corrected mixes, the uncorrected average mixes shall be used. It shall be transparently reported which energy mixes are assumed for the calculation of the benefits and whether or not these have been corrected.

Accounting for temporary (carbon) storage and delayed emissions

REQUIREMENT FOR PEF STUDIES

Credits associated with temporary (carbon) storage or delayed emissions shall not be considered in the calculation of the default EF impact categories. However, these may be included as "additional environmental information". Moreover, these shall be included under "additional environmental information" if specified in a supporting PEFCR.

5.5 Nomenclature for the Resource Use and Emissions Profile

Developers of PEF studies shall check the documented nomenclature and properties for a given flow in the Resource Use and Emissions Profile against the nomenclature and properties of the International Reference Life Cycle Data System (ILCD)[73].

REQUIREMENT FOR PEF STUDIES

All relevant resource use and emissions associated with the life cycle stages included in the defined system boundaries shall be documented using the International Reference Life Cycle Data System (ILCD) nomenclature and properties[79], as described in Annex IV.

If nomenclature and properties for a given flow are not available in the ILCD, the practitioner shall create an appropriate nomenclature and document the flow properties.

[72] European Union 2009: DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND COUNCIL of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, Official Journal of the European Union.

[73] European Commission - Joint Research Centre - Institute for Environment and Sustainability (2010f). International Reference Life Cycle Data System (ILCD) Handbook – Nomenclature and other conventions. First edition. EUR 24384. Publications Office of the European Union, Luxembourg. http://lct.jrc.ec.europa.eu/assessment/publications

5.6 Data quality requirements

This section describes how the data quality shall be assessed. Six quality criteria are adopted for PEF studies, five relating to the data and one to the method. These are summarised in Table 3. Besides these criteria, three more aspects are included in the quality assessment, i.e. review, and documentation (compliance with the ILCD format) and compliance with ILCD nomenclature. The latter three are not included within the semi-quantitative assessment of the data quality as described in the following paragraphs. These however shall be fulfilled.

Table 3: Data quality criteria, documentation, nomenclature and review

Data quality criteria	• Technological representativeness[74] • Geographical representativeness[75] • Time-related representativeness[76] • Completeness • Parameter uncertainty[77] • Methodological Appropriateness and Consistency[78] (the requirements as defined in Table 7 shall apply until end of year 2015. From 2016, full compliance with the PEF methodology will be required)
Documentation	• Compliant with ILCD format
Nomenclature	• Compliant with ILCD nomenclature (e.g. use of ILCD reference elementary flows for IT compatible inventories)
Review	• Review by "Qualified reviewer" (see chapter 8): • Separate review report

[74] The term "technological representativeness" is used throughout this Guide instead of "technological coverage" used in ISO14044.

[75] The term "geographical representativeness" is used throughout this Guide instead of "geographical coverage" used in ISO14044.

[76] The term "time-related representativeness" is used throughout this Guide instead of "time-related coverage" used in ISO14044.

[77] The term "parameter uncertainty" is used throughout this Guide instead of "precision" used in ISO14044.

[78] The term "methodological appropriateness and consistency" is used throughout this Guide instead of "consistency" used in ISO14044.

Table 4: Overview of requirements for data quality and the assessment of data quality

	Minimum data quality required	**Type of required data quality assessment**
Data covering at least 70% of contributions to each EF impact category	Overall "Good" data quality (DQR $\leq$ 3.0)	Semi-quantitative based on Table 5
Data accounting for 20-30% of contributions to each EF impact category	Overall "Fair" data quality	Qualitative expert judgement (Table 7 can be used to support the expert judgement). No quantification required.
Data used for approximation and filling identified gaps (no more than 10% of the contribution to each EF impact category)	Best available data	Qualitative expert judgement (Table 7 can be used to support the expert judgement).

Semi-quantitative assessment of data quality

Table 5 gives an overview of the criteria used for semi-quantitative assessment of data quality; Table 6 and corresponding equations describe the criteria to be used for a semi-quantitative assessment of data quality. Annex VII provides an example of data quality requirements for intermediate paper products.

Table 5: Criteria for semi-quantitative assessment of overall data quality of the Life Cycle Inventory datasets used in the EF study.

Quality level	Quality rating	Definition	Completeness	Methodological appropriateness and consistency	Time representativeness	Technological representativeness	Geographical representativeness	Parameter uncertainty
			To be judged with respect to the coverage for each EF impact category and in comparison to a hypothetical ideal data quality	The applied LCI methods and methodological choices (e.g. allocation, substitution, etc.) are in line with the goal and scope of the dataset, especially its intended applications as support to decisions. The methods have also been consistently applied across all data.[79]	Degree to which the dataset reflects the specific conditions of the system being considered regarding the time / age of the data, and including background datasets, if any. Comment: i.e. of the given year (and, if applicable, of intra-annual or intra-daily differences).	Degree to which the dataset reflects the true population of interest regarding technology, including for included background datasets, if any. Comment: i.e. of the technological characteristics including operating conditions.	Degree to which the dataset reflects the true population of interest regarding geography, including background datasets, if any. Comment: i.e. of the given location / site, region, country, market, continent, etc.	Qualitative expert judgement or relative standard deviation as a % if a Monte Carlo simulation is used. Comment: The uncertainty assessment is related to the resource use and emission data only; it does not cover the EF impact assessment.
Very good	1	Meets the criterion to a very high degree, without need	Very good completeness (≥ 90%)	Full compliance with all requirements of the PEF Guide	Context–specific	Context–specific	Context–specific	**Very low uncertainty** Very low uncertainty

[79] This requirement shall apply until end of year 2015. From year 2016 onwards, full compliance with the PEF methodology will be required.

Quality level	Quality rating	Definition	Completeness	Methodological appropriateness and consistency	Time representativeness	Technological representativeness	Geographical representativeness	Parameter uncertainty
		for improvement.						(≤ 10%)
Good	2	Meets the criterion to a high degree, with little significant need for improvement.	Good completeness (80% to 90%)	Attributional[80] process-based approach AND: Following three method requirements of the PEF Guide met: • Dealing with multi-functionality • End of life modelling • System boundary	Context–specific	Context–specific	Context–specific	**Low uncertainty** Low uncertainty (10% to 20%]
Fair	3	Meets the criterion to an acceptable degree, but merits improvement.	Fair completeness (70% to 80%)	Attributional process-based approach AND: Two of the following three method requirements of the PEF Guide met: • Dealing with multi-	Context–specific	Context–specific	Context–specific	**Fair uncertainty** Fair uncertainty (20% to 30%]

[80] Attributional - refers to process-based modeling intended to provide a static representation of average conditions

Quality level	Quality rating	Definition	Completeness	Methodological appropriateness and consistency	Time representativeness	Technological representativeness	Geographical representativeness	Parameter uncertainty
				functionality • End of life modelling • System boundary				
Poor	4	Does not meet the criterion to a sufficient degree. Requires improvement.	Poor completeness (50% to 70%)	Attributional process-based approach AND: One of the following three method requirements of the PEF Guide met: • Dealing with multi-functionality • End of life modelling • System boundary	Context–specific	Context–specific	Context–specific	**High uncertainty** High uncertainty (30% to 50%]
Very poor	5	Does not meet the criterion. Substantial improvement is necessary	Very poor or unknown completeness (< 50%)	Attributional process-based approach BUT: None of the following three method requirements of the	Context–specific	Context–specific	Context–specific	**Very high uncertainty** Very high uncertainty (> 50%)

Quality level	Quality rating	Definition	Completeness	Methodological appropriateness and consistency	Time representativeness	Technological representativeness	Geographical representativeness	Parameter uncertainty
		OR: This criterion was not judged / reviewed or its quality could not be verified / is unknown.		PEF Guide met: • Dealing with multi-functionality • End of life modelling • System boundary				

The overall data quality shall be calculated by summing up the achieved quality rating for each of the quality criteria, divided by the total number of criteria (i.e. six). The Data Quality Rating (DQR) result is used to identify the corresponding quality level in Table 6. Formula 1 provides the calculation provision:

Formula 1 $$DQR = \frac{TeR + GR + TiR + C + P + M}{6}$$

- *DQR* : *Data Quality Rating of the dataset*
- *TeR: Technological Representativeness*
- *GR: Geographical Representativeness*
- *TiR: Time-related Representativeness*
- *C: Completeness*
- *P: Precision/uncertainty*
- *M*: *Methodological Appropriateness and Consistency*

This formula**Error! Reference source not found.** shall be used to identify the overall data quality level according to the achieved data quality rating.

Table 6: overall data quality level according to the achieved data quality rating

Overall data quality rating (DQR)	Overall data quality level
≤ 1.6[81]	"Excellent quality"
1.6 to 2.0	"Very good quality"
2.0 to 3.0	"Good quality"
3 to 4.0	"Fair quality"
>4	"Poor quality"

Table 7: Example of semi-quantitative assessment of data quality required for key Life Cycle Inventory datasets. Process: dyeing process

Quality level	Quality rating	Definition	Completeness	Methodological compliance and consistency	Time representativeness	Technological representativeness	Geographical representativeness	Parameter uncertainty (relative standard deviation as a % if a Monte Carlo simulation is used, otherwise qualitative expert judgement)
Very good	1	Meets the criterion to a very high degree, without need for improvement.	Very good completeness (≥ 90%)	Full compliance with all requirements of the PEF Guide	2009-2012	Discontinuous with airflow dyeing machines	Central Europe mix	Very low uncertainty (≤ 10%)
Good	2	Meets the criterion to a high degree, with little significant need for improvement.	Good completeness (80% to 90%)	Attributional Process based approach AND: Following three method requirements of the PEF Guide met: • Dealing with multi-functionality • End of life modelling • System boundary	2006-2008	e.g. "Consumption mix in EU: 30% Semi-continuous, 50% exhaust dyeing and 20% Continuous dyeing"	EU 27 mix; UK, DE; IT; FR	Low uncertainty (10% to 20%]
Fair	3	Meets the	Fair completeness	Attributional process-	1999-2005	e.g. "Production mix	Scandinavian	Fair

Quality level	Quality rating	Definition	Completeness	Methodological compliance and consistency	Time representativeness	Technological representativeness	Geographical representativeness	Parameter uncertainty (relative standard deviation as a % if a Monte Carlo simulation is used, otherwise qualitative expert judgement)
		criterion to an acceptable degree, but merits improvement.	(70% to 80%)	based approach AND: The following two method requirements of the PEF Guide are met: • Dealing with multi-functionality • End of life modelling However, the following method requirement of the PEF Guide is not met: • System boundary		in EU: 35% Semi-continuous, 40% exhaust dyeing and 25% Continuous dyeing"	Europe; other EU-27 countries	uncertainty (20% to 30%]
Poor	4	Does not meet the criterion to a sufficient degree. Requires	Poor completeness (50% to 75%)	Attributional process-based approach AND: The following method requirement of the PEF	1990-1999	e.g. "Exhaust dyeing"	Middle east; US; JP	High uncertainty (30% to 50%]

Quality level	Quality rating	Definition	Completeness	Methodological compliance and consistency	Time representativeness	Technological representativeness	Geographical representativeness	Parameter uncertainty (relative standard deviation as a % if a Monte Carlo simulation is used, otherwise qualitative expert judgement)
		improvement.		Guide met: • Dealing with multi-functionality However, the following two method requirements of the PEF Guide are not met: • End-of-life modelling • System boundary				
Very poor	5	Does not meet the criterion. Substantial improvement is necessary OR: This criterion was not judged / reviewed or its	Very poor or unknown completeness (< 50%)	Attributional process-based approach BUT: None of the following three method requirements of the PEF Guide are met: • Dealing with multi-functionality	<1990; Unknown	Continuous dyeing; other; unknown	Other; Unknown	Very high uncertainty (> 50%)

Quality level	**Quality rating**	**Definition**	**Completeness**	**Methodological compliance and consistency**	**Time representativeness**	**Technological representativeness**	**Geographical representativeness**	**Parameter uncertainty (relative standard deviation as a % if a Monte Carlo simulation is used, otherwise qualitative expert judgement)**
		quality could not be verified / is unknown.		• End-of-life modelling • System boundary				

REQUIREMENT FOR PEF STUDIES:

Data quality requirements shall be met by PEF studies intended for external communication, i.e. B2B and B2C. For PEF studies (claiming to be in line with this PEF Guide) intended for in-house applications, the specified data quality requirements should be met (i.e. are recommended), but are not mandatory. Any deviations from the requirements shall be documented. Data quality requirements apply to both specific[82] and generic data[83].

The following six criteria shall be adopted for a semi-quantitative assessment of data quality in PEF studies: technological representativeness, geographical representativeness, time-related representativeness, completeness, parameter uncertainty and methodological appropriateness.

In the optional screening step a minimum "fair" quality data rating is required for data contributing to at least 90% of the impact estimated for each EF impact category, as assessed via a qualitative expert judgement.

In the final Resource Use and Emissions Profile, for the processes or activities accounting for at least 70% of contributions to each EF impact category, both specific and generic data shall achieve at least an overall "good quality" level (the 70% threshold is chosen to balance the goal of achieving a robust assessment with the need to keep it feasible and accessible). A semi-quantitative assessment of data quality shall be performed and reported for these processes. At least 2/3 of the remaining 30% (i.e. 20% to 30%) shall be modelled with at least "fair quality" data. Data of less than fair quality rating shall not account for more than 10% contributions to each EF impact category.

The data quality requirements for technological, geographical and time-related representativeness shall be subject to review as part of the PEF study. The data quality requirements related to completeness, methodological appropriateness and consistency, and parameter uncertainty should be met by sourcing generic data exclusively from data sources that comply with the requirements of the PEF Guide.

With respect to the data quality criterion of "methodological appropriateness and consistency", the requirements as defined in Table 6 shall apply until the end of 2015. From 2016, full compliance with the PEF methodology will be required.

The data quality assessment of generic data shall be conducted at the level of the input flows (e.g. purchased paper used in a printing office) while the data quality assessment of specific data shall be conducted at the level of an individual process or aggregated process, or at the level of individual input flows.

ADDITIONAL REQUIREMENTS FOR DEVELOPMENT OF PEFCRs

PEFCRs shall provide further guidance on data quality assessment scoring for the product category with respect to time, geographical and technological representativeness. For example, it shall specify which data

[82] Refers to directly measured or collected data representative of activities at a specific facility or set of facilities. Synonymous to "primary data."

[83] Refers to data that is not directly collected, measured, or estimated, but rather sourced from a third-party life-cycle-inventory database or other source that complies with the data quality requirements of the PEF method.

quality score relating to time representativeness should be assigned to a dataset representing a given year.

PEFCRs may specify additional criteria for the assessment of data quality (compared to default criteria).

PEFCRs may specify more stringent data quality requirements, if appropriate for the product category in question. These may include:

- Gate-to-gate activities/processes;
- Upstream or downstream phases;
- Key supply-chain activities for the product category;
- Key EF impact categories for the product category.

Example for determining the data quality rating

Component	Achieved quality level	Corresponding quality rating
Technological representativeness (TeR)	good	2
Geographical representativeness (GR)	good	2
Time-related representativeness (TiR)	fair	3
Completeness (C)	good	2
Parameter uncertainty (P)	good	2
Methodological appropriateness and consistency (M)	good	2

$$DQR = \frac{TeR + GR + TiR + C + P + M}{6} = \frac{2 + 2 + 3 + 2 + 2 + 2}{6} = 2.2$$

A DQR of 2.2 corresponds to an overall “good quality” rating.

5.7 Specific data collection

This section describes the collection of specific data which are data directly measured or collected representative of activities at a specific facility or set of facilities. The data should include all known inputs and outputs for the processes. Inputs are (for example) use of energy, water, materials, etc. Outputs are the products, co-products[84], and emissions. Emissions can be divided into four categories: emissions to air, to water, to soil, and emissions as solid waste. Specific data can be collected, measured or calculated using activity data[85] and related emission factors. It should be noted that emission factors may be derived from generic data subject to data quality requirements.

[84] Co-product – any of two or more products coming from the same unit process or product system (ISO 14040:2006)

[85] Activity data are data that are specific to the process being considered, as opposed to generic data.

Data collection - measurements and tailored questionnaires

The most representative sources of data for specific processes are measurements directly performed on the process, or obtained from operators via interviews or questionnaires. The data may need scaling, aggregation or other forms of mathematical treatment to bring them in line with the unit of analysis and reference flow of the process.

Typical specific data sources are:

- Process- or plant-level consumption data;
- Bills and stock/inventory changes of consumables;
- Emission measurements (amounts and concentrations of emissions from gas and wastewater);
- Composition of products and waste;
- Procurement and sale department(s)/unit(s).

REQUIREMENT FOR PEF STUDIES

Specific data[86] shall be obtained for all foreground processes and for background processes, where appropriate[87]. However, if generic data are more representative or appropriate than specific data for foreground processes (to be justified and reported), generic data shall also be used for the foreground processes.

ADDITIONAL REQUIREMENTS FOR DEVELOPMENT OF PEFCRs

PEFCRs shall:

1. Specify for which processes specific data shall be collected;
2. Specify the requirements for the collection of specific data;
3. Define the data collection requirements for each site for:
   - Target stage(s) and the data collection coverage;
   - Location of data collection (domestically, internationally, specific factories, and so on);
   - Term of data collection (year, season, month, and so on);
   - When the location or term of data collection must be limited to a certain range, provide a justification for this and show that the collected data will serve as sufficient samples.

[86] Including average data representing multiple sites. Average data **r**efers to a production-weighted average of specific data.
[87] A definition of “foreground” and “background” processes is provided in the Glossary.

5.8 Generic data collection

Generic data refers to data that are not based on direct measurements or calculation of the respective processes in the system. Generic data can be either sector-specific, i.e. specific to the sector being considered for the PEF study, or multi-sector. Examples of generic data include:

- Data from literature or scientific papers;
- Industry-average life-cycle data from life-cycle-inventory databases, industry association reports, government statistics, etc.

Sourcing generic data

Generic data should where available be sourced from the data sources specified in this PEF Guide. Remaining generic data should preferentially be sourced from:

- Databases provided by international governmental organisations (for example FAO, UNEP);
- Country-specific national governmental LCI database projects (for data specific to the host country's database);
- National governmental LCI database projects;
- Other third-party LCI databases;
- Peer-reviewed literature.

Other potential sources of generic data can also be found, e.g. in the Resource Directory of the European Platform on LCA[88]. If the necessary data cannot be found in the above-listed sources, other sources may be used.

REQUIREMENT FOR PEF STUDIES

Generic data should be used only for processes in the background system. When available, sector-specific generic data shall be used instead of multi-sector generic data. All generic data shall fulfil the data quality requirements specified in this document. The sources of the data used shall be clearly documented and reported in the PEF report.

Generic data (provided they fulfil the data quality requirements specified in this PEF Guide) should, where available, be sourced from:

- Data developed in line with the requirements of the relevant PEFCRs;
- Data developed in line with the requirements for PEF studies;
- International Reference Life Cycle Data System (ILCD) Data Network[89] (giving preference to datasets that are fully compliant with the ILCD Data Network over those that are only entry-level compliant);
- International Reference Life Cycle Data System (ELCD) database[90].

[88] http://lca.jrc.ec.europa.eu/lcainfohub/datasetArea.vm
[89] http://lct.jrc.ec.europa.eu/assessment/data
[90] http://lct.jrc.ec.europa.eu/assessment/data

ADDITIONAL REQUIREMENT FOR PEFCRs:

The PEFCR shall specify:

- where the use of generic data is permitted as an approximation for a substance for which specific data is not available;
- the level of required similarities between the actual substance and the generic substance;
- the combination of more than one generic dataset, if necessary.

5.9 Dealing with remaining unit process data gaps / missing data

Data gaps exist when there is no specific or generic data available that is sufficiently representative of the given process in the product's life cycle. For most processes where data may be missing it should be possible to obtain sufficient information to provide a reasonable estimate of the missing data. Therefore, there should be few, if any, data gaps in the final Resource Use and Emissions Profile. Missing information can be of different types and have different characteristics, each requiring separate resolution approaches.

Data gaps may exist when:

- Data does not exist for a specific input/product, or
- Data exists for a similar process but:
  - The data has been generated in a different region;
  - The data has been generated using a different technology;
  - The data has been generated in a different time period.

REQUIREMENT FOR PEF STUDIES

Any data gaps shall be filled using the best available generic or extrapolated data[91]. The contribution of such data (including gaps in generic data) shall not account for more than 10% of the overall contribution to each EF impact category considered. This is reflected in the data quality requirements, according to which 10% of the data can be chosen from the best available data (without any further data quality requirements).

ADDITIONAL REQUIREMENT FOR DEVELOPMENT OF PEFCRs

The PEFCR shall specify potential data gaps and provide detailed guidance for filling these gaps.

5.10 Handling multi-functional processes

If a process or facility provides more than one function, i.e. it delivers several goods and/or services ("co-products"), it is "multifunctional". In these situations, all inputs and emissions linked to the process must be partitioned between the product of interest and the other co-products in a principled manner. Systems

[91] Extrapolated data **r**efers to data from a given process that is used to represent a similar process for which data is not available, on the assumption that it is reasonably representative.

involving multi-functionality of processes shall be modelled in accordance with the following decision hierarchy, with additional guidance provided by PEFCRs if available.

Decision hierarchy

I) Subdivision or system expansion

Wherever possible, subdivision or system expansion should be used to avoid allocation. Subdivision refers to disaggregating multifunctional processes or facilities to isolate the input flows directly associated with each process or facility output. System expansion refers to expanding the system by including additional functions related to the co-products. It shall be investigated first whether the analysed process can be subdivided or expanded. Where subdivision is possible, inventory data should be collected only for those unit processes[92] directly attributable[93] to the goods/services of concern. Or if the system can be expanded, the additional functions shall be included in the analysis with results communicated for the expanded system as a whole rather than on an individual co-product level.

II) Allocation based on a relevant underlying physical relationship

Where subdivision or system expansion cannot be applied, allocation should be applied: the inputs and outputs of the system should be partitioned between its different products or functions in a way that reflects relevant underlying physical relationships between them. (ISO 14044:2006, 14)

Allocation based on a relevant underlying physical relationship refers to partitioning the input and output flows of a multi-functional process or facility in accordance with a relevant, quantifiable physical relationship between the process inputs and co-product outputs (for example, a physical property of the inputs and outputs that is relevant to the function provided by the co-product of interest). Allocation based on a physical relationship can be modelled using direct substitution if a product can be identified that is directly substituted[94].

Can a direct substitution-effect be robustly modelled? This can be demonstrated by proving that (1) there is a direct, empirically demonstrable substitution effect, AND (2) the substitute product can be modelled and the inventory subtracted in a directly representative manner:

- If yes (i.e. both conditions are verified), model the substitution effect.

Or

Can input/output flows be allocated based on some other relevant underlying physical relationship that relates the inputs and outputs to the function provided by the system? This can be demonstrated by proving that a relevant physical relationship can be defined by which to allocate the flows attributable to the provision of the defined function of the product system[95]:

- If yes, allocate based on this physical relationship.

[92] A unit process is the smallest element considered in the Resource Use and Emissions Profile for which input and output data are quantified. (based on ISO 14040:2006)

[93] Directly attributable refers to a process, activity or impact occurring within the defined system boundary.

[94] See below for an example of direct substitution.

[95] A product system is the collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product (ISO 14040:2006)

III) Allocation Based on Some Other Relationship

Allocation based on some other relationship may be possible. For example, economic allocation refers to allocating inputs and outputs associated with multi-functional processes to the co-product outputs in proportion to their relative market values. The market price of the co-functions should refer to the specific condition and point at which the co-products are produced. Allocation based on economic value shall only be applied when (I and II) are not possible. In any case, a clear justification shall be provided, with reference to ensuring the physical representativeness of the PEF results.

Allocation based on some other relationship can be approached in one of the following alternative ways:

Can an indirect substitution[96] effect be identified? AND can the substituted product be modelled and the inventory subtracted in a reasonably representative manner?

- If yes (i.e. both conditions are verified), model the indirect substitution effect.

Or

Can the inputs between the products and functions be allocated on the basis of some other relationship (e.g. the relative economic value of the co-products)?

- If yes, allocate products and functions on the basis of the identified relationship

Dealing with multi-functionality of products is particularly challenging when recycling or energy recovery of one (or more) of these products is involved as the systems tend to get rather complex. Annex V provides an approach that shall be used to estimate the overall emissions associated to a certain process involving recycling and/or energy recovery. These moreover also relate to waste flows generated within the system boundaries.

Examples of direct and indirect substitution

Direct Substitution:

Direct substitution may be modelled as a form of allocation based on an underlying physical relationship when a direct, empirically-demonstrable substitution effect can be identified. For example, when manure nitrogen is applied to agricultural land, directly substituting an equivalent amount of the specific fertiliser nitrogen that the farmer would otherwise have applied, the animal husbandry system from which the manure is derived is credited for the displaced fertiliser production (taking into account differences in transportation, handling, and emissions).

Indirect Substitution:

Indirect substitution may be modelled as a form of “allocation based on some other relationship” when a co-product is assumed to displace a marginal or average market-equivalent product via market-mediated processes. For example, when animal manure is packaged and sold for use in home gardening, the animal husbandry system from which the manure is derived is credited for the market-average home gardening fertiliser that is assumed to have been displaced (taking into account differences in transportation, handling, and emissions).

[96] Indirect substitution occurs when a product is substituted but you don’t know by which products exactly.

REQUIREMENT FOR PEF STUDIES

The following PEF multi-functionality decision hierarchy shall be applied for resolving all multi-functionality problems: (1) subdivision or system expansion; (2) allocation based on a relevant underlying physical relationship (including direct substitution or some relevant underlying physical relationship); (3) allocation based on some other relationship (including indirect substitution or some other relevant underlying relationship).

All choices made in this context shall be reported and justified with respect to the overarching goal of ensuring physically representative, environmentally relevant results. For multi-functionality of products in recycling or energy recovery situations, the equation described in Annex V shall be applied. The abovementioned decision process also applies for end-of-life multi-functionality.

ADDITIONAL REQUIREMENT FOR DEVELOPMENT OF PEFCRs

The PEFCR shall further specify multi-functionality solutions for application within the defined system boundaries and, where appropriate, for upstream and downstream stages. If feasible/appropriate, the PEFCR may further provide specific factors to be used in the case of allocation solutions. All such multi-functionality solutions specified in the PEFCR must be clearly justified with reference to the PEF multi-functionality solution hierarchy.

Where subdivision is applied, the PEFCR shall specify which processes are to be sub-divided and the principles that such subdivision should adhere to.

Where allocation by physical relationship is applied, the PEFCR shall specify the relevant underlying physical relationships to be considered, and establish the relevant allocation factors.

Where allocation by some other relationship is applied, the PEFCR shall specify this relationship and establish the relevant allocation factors. For example, in the case of economic allocation, the PEFCR shall specify the rules for determining the economic values of co-products.

For multi-functionality in end-of-life situations, the PEFCR shall specify how the different parts are calculated within the mandatory formula provided.

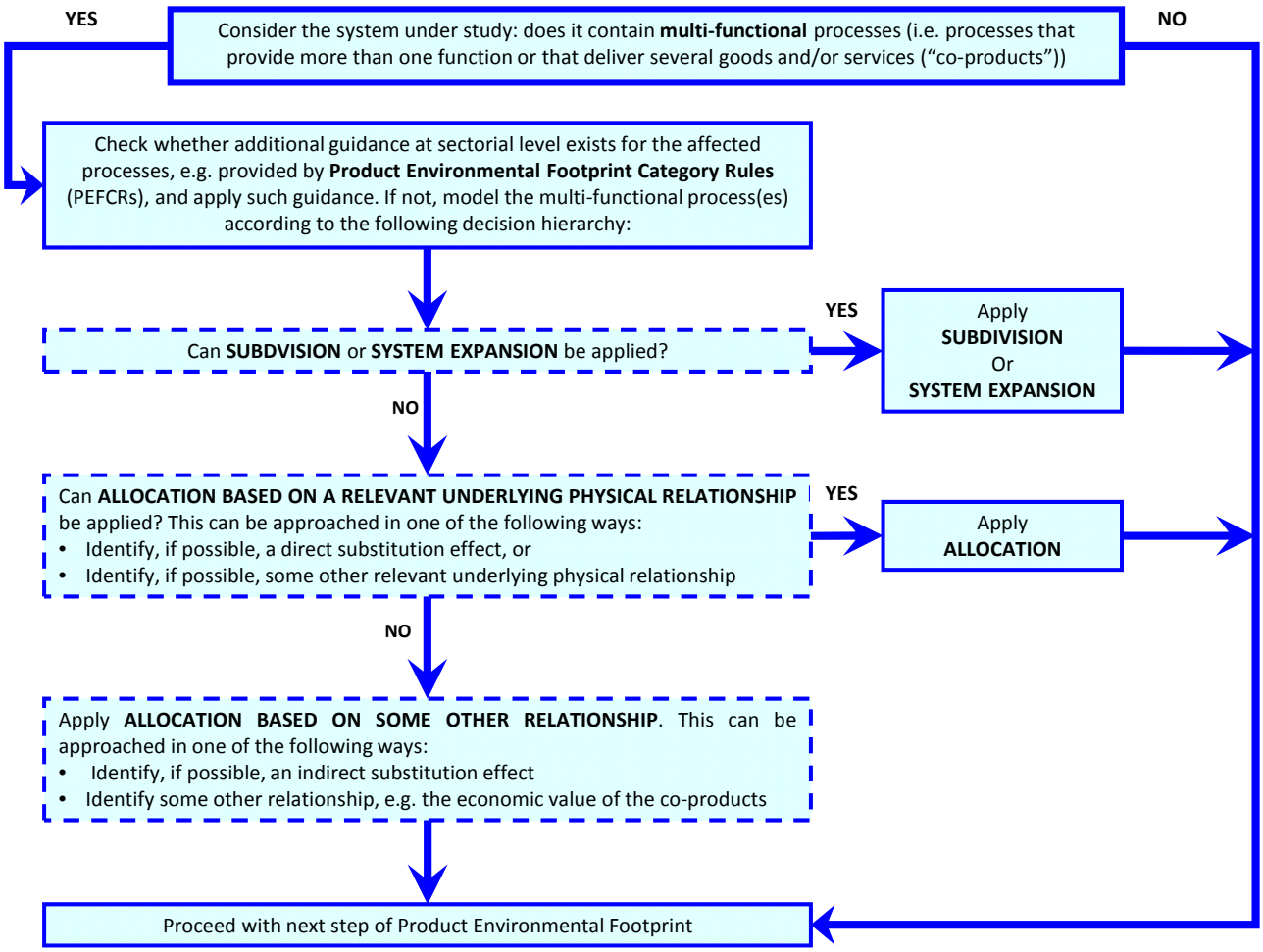

Figure 4: Decision tree for handling multi-functional processes

5.11 Data gathering related to the next methodological phases in a PEF study

Figure 5 focuses on the data collection step to be taken when developing a PEF study. The "shall/should/may" requirements are summarised for both specific and generic data. The figure moreover indicates the link between the data collection step and the development of the Resource Use and Emissions Profile and subsequent EF impact assessment.

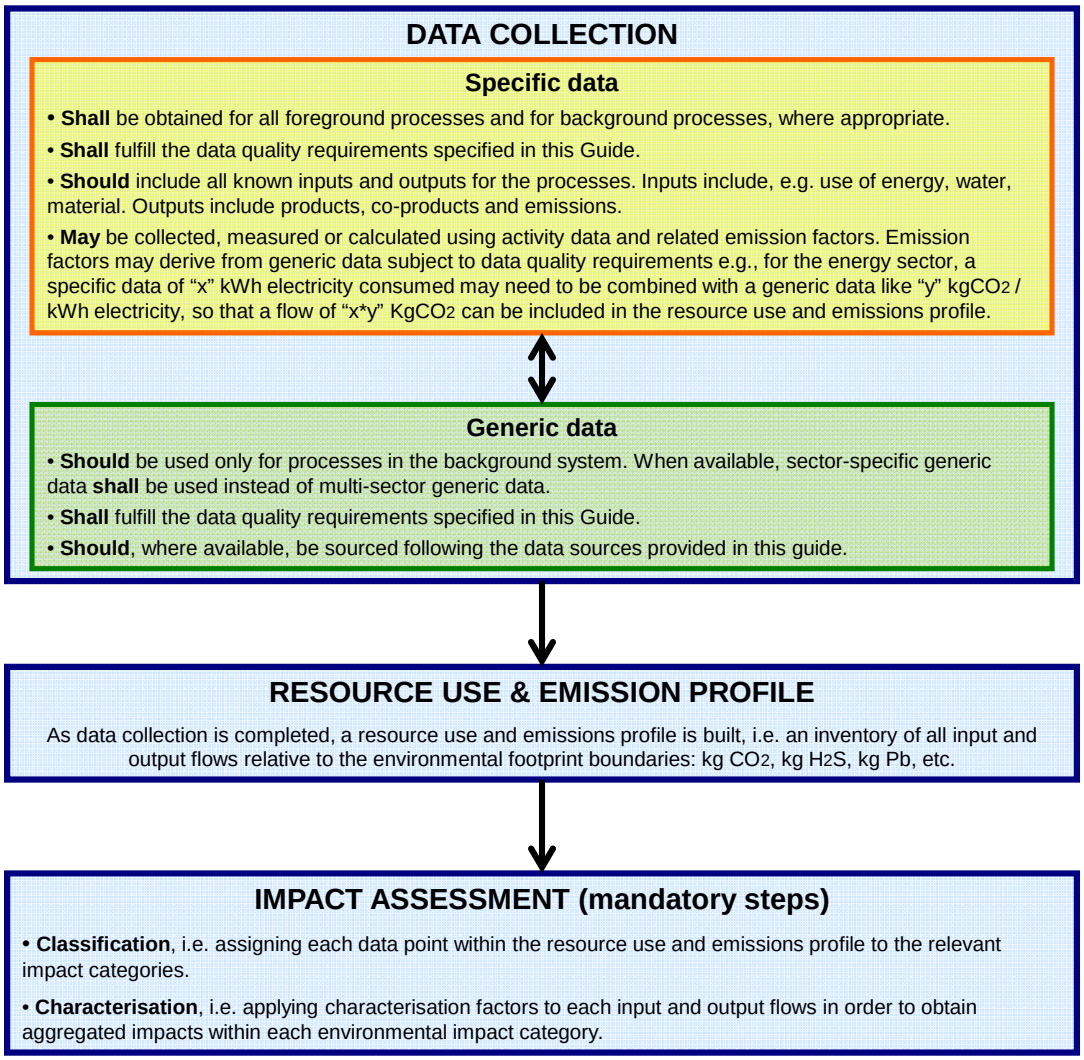

Figure 5: Relationship between data collection, Resource Use and Emissions Profile and EF impact assessment.

6. Environmental Footprint Impact Assessment

Once the Resource Use and Emissions Profile has been compiled, the EF impact assessment shall be undertaken to calculate the environmental performance of the product, using the selected EF impact categories and models. EF impact assessment includes two mandatory and two optional steps. The EF Impact Assessment does not intend to replace other (regulatory) tools that have a different scope and objective such as (Environmental) Risk Assessment ((E)RA), site specific Environmental Impact Assessment (EIA) or Health and Safety regulations at product level or related to safety at the workplace. Especially, the EF Impact Assessment has not the objective to predict if at any specific location at any specific time thresholds are exceeded and actual impacts occur. In contrast it describes the existing pressures on the environment. Thus, the EF Impact Assessment is complementary to other well-proven tools adding the life cycle perspective.

6.1 Mandatory Steps: Classification and Characterisation

REQUIREMENT FOR PEF STUDIES

The EF impact assessment shall include a classification and characterisation of the Product Environmental Footprint flows.

6.1.1 Classification of Product Environmental Footprint Flows

Classification requires assigning the material/energy inputs and outputs inventoried in the Resource Use and Emissions Profile to the relevant EF impact category. For example, during the classification phase, all inputs/outputs that result in greenhouse gas emissions are assigned to the Climate Change category. Similarly, those that result in emissions of ozone-depleting substances are classified accordingly to the Ozone Depletions category. In some cases, an input/output may contribute to more than one EF impact category (for example, chlorofluorocarbons (CFCs) contribute to both Climate Change and Ozone Depletion).

It is important to express the data in terms of the constituent substances for which characterisation factors (see next section) are available. For example, data for a composite NPK fertiliser should be disaggregated and classified according to its N, P, and K fractions, because each constituent element will contribute to different EF impact categories. In practice, much of the Resource Use and Emissions Profile data may be drawn from existing public or commercial life-cycle-inventory databases, where classification has already been implemented. In such cases, it must be assured, for example by the provider, that the classification and linked EF impact assessment pathways correspond to the requirements of this PEF Guide.

REQUIREMENT FOR PEF STUDIES

All inputs/outputs inventoried during the compilation of the Resource Use and Emissions Profile shall be assigned to the EF impact categories to which they contribute (“classification”) using the classification data available at http://lct.jrc.ec.europa.eu/assessment/projects.

As part of the classification of the Resource Use and Emissions Profile, data should be expressed in terms of constituent substances for which characterisation factors are available.

Example: classification of data for a T-Shirt study

Classification of data in the climate change impact category:

CO_2	Yes
CH_4	Yes
SO_2	No
NO_x	No

Classification of data in the acidification impact category:

CO_2	No
CH_4	No
SO_2	Yes
NO_x	Yes

6.1.2 Characterisation of Environmental Footprint Flows

Characterisation refers to the calculation of the magnitude of the contribution of each classified input/output to their respective EF impact categories, and aggregation of the contributions within each category. This is carried out by multiplying the values in the Resource Use and Emissions Profile by the relevant characterisation factor for each EF impact category.

The characterisation factors are substance- or resource- specific. They represent the impact intensity of a substance relative to a common reference substance for an EF impact category (impact category indicator). For example, in the case of calculating climate change impacts, all greenhouse gas emissions inventoried in the Resource Use and Emissions Profile are weighted in terms of their impact intensity relative to carbon dioxide, which is the reference substance for this category. This allows for the aggregation of impact potentials and expression in terms of a single equivalent substance (in this case, CO_2 equivalents) for each EF impact category. For example, the characterisation factors expressed as global warming potential for methane equals 25 CO_2 equivalents compared to the 1 CO_2 equivalent of 1 CO_2.

REQUIREMENT FOR PEF STUDIES

All classified inputs/outputs in each EF impact category shall be assigned characterisation factors representing the contribution per unit of input/output to the category, using the provided characterisation factors available online at http://lct.jrc.ec.europa.eu/assessment/projects. EF impact assessment results shall subsequently be calculated for each EF impact category by multiplying the amount of each input/output by its characterisation factor and summing the contributions of all inputs/outputs within each category to a single measure expressed in the appropriate reference unit.

If characterisation factors (CFs) from the default model are not available for certain flows (e.g. a group of chemicals) of the Resource Use and Emissions Profile, then other approaches may be used for characterising these flows. In such circumstances, this shall be reported under "additional environmental information". The characterisation models shall be scientifically and technically valid, and based upon distinct, identifiable environmental mechanisms[97] or reproducible empirical observations.

[97] An environmental mechanism is defined as a system of physical, chemical and biological processes for a given EF impact category linking the Resource Use and Emissions Profile results to EF category indicators. (based on ISO 14040:2006)

Example: Calculation of EF impact assessment

Global warming

			CF		
CO_2 g	5,132	x	1	=	5.132 kg CO_2eq
CH_4 g	8.2	x	25	=	0.205 kg CO_2eq
SO_2 g	3.9	x	0	=	0 kg CO_2eq
NO_x g	26.8	x	0	=	0 kg CO_2eq
			Total	=	5.337 kg CO_2eq

Acidification

			CF		
CO_2 g	5,132	x	0	=	0 Mol H+ eq
CH_4 g	8.2	x	0	=	0 Mol H+ eq
SO_2 g	3.9	x	1.31	=	0.005 Mol H+ eq
NO_x g	26.8	x	0.74	=	0.019 Mol H+ eq
			Total	=	0.024kg Mol H+ eq

6.2 Optional Steps: Normalisation and Weighting

Following the two mandatory steps of classification and characterisation, the EF impact assessment may be complemented with normalisation and weighting, which are optional steps.

6.2.1 Normalisation of Environmental Footprint Impact Assessment Results

Normalisation is an optional step in which the EF impact assessment results are multiplied by normalisation factors in order to calculate and compare the magnitude of their contributions to the EF impact categories relative to a reference unit (typically the pressure related to that category caused by the emissions over one year of a whole country or an average citizen). As a result, dimensionless, normalised EF results are obtained. These reflect the burdens attributable to a product relative to the reference unit, such as per capita for a given year and region. This allows the relevance of the contributions made by individual processes to be compared to the reference unit of the EF impact categories considered. For example, EF impact assessment results may be compared to the same EF impact assessment results for a given region such as the EU-27 and on a per-person basis. In this case they would reflect person-equivalents relative to the emissions associated with the EU-27. Normalised environmental footprint results do not, however, indicate the severity/relevance of the respective impacts.

REQUIREMENT FOR PEF STUDIES

Normalisation is not a required step for PEF studies. If normalisation is applied, the normalised environmental footprint results shall be reported under “additional environmental information”, with all methods and assumptions documented.

Normalised results shall not be aggregated as this implicitly applies weighting. Results from the EF impact assessment prior to normalisation shall be reported alongside the normalised results.

6.2.2 Weighting of Environmental Footprint Impact Assessment Results

Weighting is an additional optional step that may support the interpretation and communication of the results of the analysis. In this step, EF results, for example normalised results, are multiplied by a set of weighting factors which reflect the perceived relative importance of the EF impact categories considered. Weighted EF results can then be compared to assess their relative importance. They can also be aggregated across EF impact categories to obtain several aggregated values or a single overall impact indicator.

Weighting requires making value judgements as to the respective importance of the EF impact categories considered. These judgements may be based on expert opinion, cultural/political viewpoints, or economic considerations.[98]

REQUIREMENT FOR PEF STUDIES.

Weighting is not a required step for PEF studies. If weighting is applied, the methods and results shall be reported under "additional environmental information". Results of the EF impact assessment prior to weighting shall be reported alongside weighted results.

The application of normalisation and weighting steps in PEF studies shall be consistent with the defined goals and scope of the study, including the intended applications.[99]

[98] For more information on existing weighting approaches in Life Cycle Impact Assessment, please refer to the reports developed by the JRC and CML entitled "Background review of existing weighting approaches in LCIA" and "Evaluation of weighting methods for measuring the EU-27 overall environmental impact". These are available online at http://lct.jrc.ec.europa.eu/assessment/publications

[99] It should be noted that ISO 14040 and 14044 do not permit the use of weighting in support of comparative assertions intended to be disclosed to the public.

7. Interpretation of Product Environmental Footprint results

7.1 General

Interpretation of the results of the PEF[100] study serves two purposes:

- The first is to ensure that the performance of the PEF model corresponds to the goals and quality requirements of the study. In this sense, PEF interpretation may inform iterative improvements of the PEF model until all goals and requirements are met;
- The second purpose is to derive robust conclusions and recommendations from the analysis, for example in support of environmental improvements.

To meet these objectives, the PEF interpretation phase shall include four key steps, as outlined in this chapter.

REQUIREMENT FOR PEF STUDIES

The interpretation phase shall include the following steps: “assessment of the robustness of the PEF model”; “identification of hotspots”; “estimation of uncertainty”; and “conclusions, limitations and recommendations”.

7.2 Assessment of the robustness of the Product Environmental Footprint model

The assessment of the robustness of the PEF model assesses the extent to which methodological choices such as system boundaries, data sources, allocation choices, and coverage of EF impact categories influence the analytical outcomes.

Tools that should be used to assess the robustness of the PEF model include:

- **Completeness checks**: assess the Resource Use and Emissions Profile data to ensure that it is complete relative to the defined goals, scope, system boundaries and quality criteria. This includes completeness of process coverage (i.e. all processes at each supply-chain stage considered have been included) and input/output coverage (i.e. all material or energy inputs and emissions associated with each process have been included).
- **Sensitivity checks**: assess the extent to which the results are determined by specific methodological choices, and the impact of implementing alternative choices where these are identifiable. It is useful to structure sensitivity checks for each phase of the PEF study, including goal and scope definition, the Resource Use and Emissions Profile, and the EF impact assessment.
- **Consistency checks**: assess the extent to which assumptions, methods, and data quality considerations have been applied consistently throughout the PEF study.

[100] The term “environmental footprint interpretation” is used throughout this Guide in place of the term “life cycle interpretation” used in ISO 14044.

Any issues flagged in this evaluation may be used to inform iterative improvements to the PEF study.

REQUIREMENT FOR PEF STUDIES:

The assessment of the robustness of the PEF model shall include an assessment of the extent to which methodological choices influence the results. These choices shall correspond to the requirements specified in this PEF Guide and shall be appropriate to the context. Tools that should be used to assess the robustness of the PEF model are completeness checks, sensitivity checks and consistency checks.

7.3 Identification of Hotspots

Once it has been ensured that the PEF model is robust and conforms to all aspects defined in the goal and scope definition phases, the next step is to identify the main contributing elements to the PEF results. This step may also be referred to as "hotspot" or "weak point" analysis. Contributing elements may be specific life-cycle stages, processes, or individual material/energy inputs/outputs associated with a given stage or process in the product supply chain. These are identified by systematically reviewing the PEF study results. Graphical tools may be particularly useful in this context. Such analyses provide the necessary basis to identify improvement potentials associated with specific management interventions.

REQUIREMENT FOR PEF STUDIES

PEF results shall be evaluated to assess the effect of supply-chain hotspots/weak points at the level of the input/output-, process-, and supply-chain stage and to assess potential improvements.

REQUIREMENT FOR PEFCR

The PEFCR shall identify the most relevant EF impact categories for the sector. Normalisation and weighting may be used to achieve such prioritisation.

7.4 Estimation of Uncertainty

Estimating the uncertainties of the final PEF results supports iterative improvement of PEF studies. It also helps the target audience to assess the robustness and applicability of the PEF study results.

There are two key sources of uncertainty in PEF studies:

(1) Stochastic uncertainties for "Resource Use and Emissions Profile" data

Stochastic uncertainties (both parameter and model) refer to statistical descriptions of variance around a mean/average. For normally distributed data, this variance is typically described in terms of an average and standard deviation. PEF results that are calculated using average data (i.e. the mean of multiple data points for a given process) do not reflect the uncertainty associated with such variance. However, uncertainty may be estimated and communicated using appropriate statistical tools.

(2) Choice-related uncertainties

Choice-related uncertainties arise from methodological choices including modelling principles, system boundaries, allocation choices, choice of EF impact assessment methods, and other assumptions related to time, technology, geography, etc. These are not readily amenable to statistical description, but rather can only be characterised via scenario model assessments (e.g. modelling worst- and best-case scenarios for significant processes) and sensitivity analyses.

REQUIREMENT FOR PEF STUDIES

At least a qualitative description of the uncertainties of the PEF results shall be provided for both choice-related uncertainties and uncertainties of inventory data, in order to facilitate an overall appreciation of the uncertainties of the PEF study results.

REQUIREMENT FOR PEFCRs

The PEFCR shall describe the uncertainties common to the product category and should identify the range in which results could be seen as not being significantly different in comparisons or comparative assertions.

TIP: Quantitative uncertainty assessments may be calculated for variance associated with the Resource Use and Emissions Profile data using, for example, Monte Carlo simulations. The influence of choice-related uncertainties should be estimated at the upper and lower bounds through sensitivity analyses based on scenario assessments. These should be clearly documented and reported.

7.5 Conclusions, Recommendations and Limitations

The final aspect of the EF interpretation phase is to draw conclusions based on the analytical results, answer the questions posed at the outset of the PEF study, and advance recommendations appropriate to the intended audience and context whilst explicitly taking into account any limitations to the robustness and applicability of the results. The PEF needs to be seen as complementary to other assessments and instruments such as site specific environmental impact assessments or chemical risk assessments.

Potential improvements should be identified such, as for example, cleaner technology techniques, changes in product design, environmental management systems (e.g. Eco-Management and Audit Scheme (EMAS) or ISO 14001), or other systematic approaches.

REQUIREMENT FOR PEF STUDIES

Conclusions, recommendations and limitations shall be described in accordance with the defined goals and scope of the PEF study. PEF studies intended to support comparative assertions to be disclosed to the public (i.e. claims about the environmental superiority or equivalence of the product) shall be based both on this PEF Guide and related PEFCRs. The conclusions should include a summary of identified supply chain “hotspots” and the potential improvements associated with management interventions.

8. Product Environmental Footprint Reports

8.1 General

A PEF report provides a relevant, comprehensive, consistent, accurate, and transparent account of the study and of the calculated environmental impacts associated with the product. It reflects the best possible information in such a way as to maximise its usefulness to intended current and future users, whilst honestly and transparently communicating limitations. Effective PEF reporting requires that several criteria, both procedural (report quality) and substantive (report content), are met.

8.2 Reporting elements

A PEF report consists of at least three elements: a Summary, the Main Report, and an Annex. Confidential and proprietary information can be documented in a fourth element - a complementary Confidential Report. Review reports are either annexed or referenced.

8.2.1 First element: Summary

The Summary shall be able to stand alone without compromising the results and conclusions/recommendations (if included). The Summary shall fulfil the same criteria about transparency, consistency, etc. as the detailed report. The Summary shall, as a minimum, include:

- Key elements of the goal and scope of the study with relevant limitations and assumptions;
- A description of the system boundary;
- The main results from the Resource Use and Emissions Profile and the EF impact assessment components: these shall be presented in such a way as to ensure the proper use of the information;
- If applicable, environmental improvements compared to previous periods;
- Relevant statements about data quality, assumptions and value judgements;
- A description of what has been achieved by the study, any recommendations made and conclusions drawn;
- Overall appreciation of the uncertainties of the results.

8.2.2 Second element: Main Report

The Main Report[101] shall, as a minimum, include the following components:

- **Goal of the study**:

Mandatory reporting elements include, as a minimum:

  - Intended application(s);
  - Methodological or EF impact category limitations;
  - Reasons for carrying out the study;
  - Target audience;

[101] The Main Report, as defined here, is insofar as possible in line with ISO 14044 requirements on reporting for studies which do not contain comparative assertions to be disclosed to the public.

- Whether the study is intended for comparison or for comparative assertions to be disclosed to the public;
- Reference PEFCRs;
- Commissioner of the study.

- **Scope of the study**:

The Scope of the study shall identify the analysed system in detail and address the overall approach used to establish the system boundaries. The Scope of the study shall also address data quality requirements. Finally, the Scope shall include a description of the methods applied for assessing potential environmental impacts and which EF impact categories, methods, normalisation and weighting criteria are included.

Mandatory reporting elements include, as a minimum:

- Unit of analysis and reference flow;
- System boundaries, including omissions of life-cycle stages, processes or data needs, quantification of energy and material inputs and outputs, assumptions about electricity production, use and end-of-life stages;
- The reasons for and potential significance of any exclusions;
- All assumptions and value judgements, along with justifications for the assumptions made;
- Data representativeness, appropriateness of data, and types/ sources of required data and information;
- PEF impact categories, models and indicators;
- normalisation and weighting factors (if used);
- Treatment of any multi-functionality issues encountered in the PEF modelling activity.

- **Compiling and recording the Resource Use and Emissions Profile**:

Mandatory reporting elements include, as a minimum:

- Description and documentation of all unit process[102] data collected;
- Data collection procedures;
- Sources of published literature;
- Information on any use and end-of-life scenarios considered in downstream stages;
- Calculation procedures;
- Validation of data, including documentation and justification of allocation procedures;
- If a sensitivity analysis[103] has been conducted, this shall be reported.

- **Calculating PEF impact assessment results:**

Mandatory reporting elements include:

- The EF impact assessment procedure, calculations and results of the PEF study;

[102] A unit process is the smallest element considered in the Resource Use and Emissions Profile for which input and output data are quantified (based on ISO 14040:2006).

[103] Sensitivity analyses are systematic procedures for estimating the effects of the choices made regarding methods and data on the results of a PEF study (based on ISO 14040:2006).

- Limitation of the EF results relative to the defined goal and scope of the PEF study;
- The relationship of the EF impact assessment results to the defined goal and scope;
- If any exclusion from the default EF impact categories has been made, the justification for the exclusion(s) shall be reported;
- If any deviation from the default EF impact assessment methods has been made (which shall be justified and included under additional environmental information), then the mandatory reporting elements shall also include:
    - Impact categories and impact category indicators considered, including a rationale for their selection and a reference to their source;
    - Description of or reference to all characterisation models, characterisation factors and methods used, including all assumptions and limitations;
    - Description of or reference to all value-choices used in relation to the EF impact categories, characterisation models, characterisation factors, normalisation, grouping, weighting and a justification for their use and their influence on the results, conclusions and recommendations;
    - A statement and justification of any grouping of the EF impact categories;
    - Any analysis of the indicator results, for example sensitivity and uncertainty analysis or the use of environmental data, including any implication for the results;
- Additional environmental information, if any;
- Information on carbon storage in products;
- Information on delayed emissions;
- data and indicator results reached prior to any normalisation;
- If included, normalisation and weighting factors and results.

- **Interpreting PEF results:**

Mandatory reporting elements include:

- Assessment of data quality;
- Full transparency of value choices, rationale and expert judgements;
- Identification of environmental hotspots;
- Uncertainty (at least a qualitative description);
- Conclusions, recommendations, limitations, and improvement potentials.

8.2.3 Third element: Annex

The Annex serves to document supporting elements to the main report which are of a more technical nature. It shall include:

- Descriptions of all assumptions, including those assumptions that have been shown to be irrelevant;
- Critical review report, including (where applicable) the name and affiliation of reviewer or review team, a critical review, responses to recommendations (if any);
- Resource Use and Emissions Profile (optional if considered sensitive and communicated separately in the Confidential Report, see below);
- Reviewers' self-declaration of their qualification, stating how many points they achieved for each criterion defined in section 10.3 of this PEF Guide.

8.2.4 Fourth element: Confidential Report

The Confidential Report is an optional reporting element that shall contain all those data (including raw data) and information that are confidential or proprietary and cannot be made externally available. It shall be made available confidentially to the critical reviewers.

REQUIREMENT FOR PEF STUDIES

Any PEF study intended for external communications shall include a PEF study report, which shall provide a robust basis for assessing, tracking, and seeking to improve the environmental performance of the product over time. The PEF study report shall include, at a minimum, a Summary, a Main Report and an Annex. These shall contain all the elements specified in this chapter. Any additional supporting information may also be included, for example a Confidential Report.

ADDITIONAL REQUIREMENTS FOR DEVELOPMENT OF PEFCRs

PEFCRs shall specify and justify any deviations from the default reporting requirements, and any additional and/or differentiate reporting requirements that depend on, for example, the type of applications of the PEF study and the type of product being assessed. The PEFCRs shall specify whether the PEF results shall be reported separately for each of the selected life cycle stages.

9. Product Environmental Footprint Critical Review

9.1 General[104]

Critical review is essential to ensuring the reliability of the PEF results and to improving the quality of the PEF study.

REQUIREMENT FOR PEF STUDIES

Any PEF study intended for external communication (e.g. B2B or B2C) shall be critically reviewed in order to ensure that:

- The methods used to carry out the PEF study are consistent with this PEF Guide;
- The methods used to carry out the PEF study are scientifically and technically valid;
- The data used are appropriate, reasonable and meet the defined data quality requirements;
- The interpretation of results reflects the limitations identified;
- The study report is transparent, accurate and consistent.

9.2 Review Type

The most suitable review type that provides the required minimum guarantee of quality assurance is an independent external review. The type of review conducted should be informed by the goals and intended applications of the PEF study.

REQUIREMENT FOR PEF STUDIES

Unless otherwise specified in relevant policy instruments, any study intended for external communication[105] shall be critically reviewed by at least one independent and qualified external reviewer (or review team). A PEF study to support a comparative assertion intended to be disclosed to the public shall be based on relevant PEFCRs and critically reviewed by an independent panel of three qualified external reviewers.

The type of review conducted should be informed by the goals and intended applications of the PEF study.

REQUIREMENT FOR PEFCRs

The PEFCR shall specify the review requirements for PEF studies intended to be used for comparative assertions to be disclosed to the public (e.g. whether a review by at least three independent qualified external reviewers is sufficient).

[104] This section builds upon the Greenhouse Gas Protocol's Product Life Cycle Accounting and Reporting Standard, 2011 – Chapter 12.3.

[105] See section 1.1, Table 1.

9.3 Reviewer Qualification

The assessment of the appropriateness of potential reviewers is based on a scoring system that takes into account review and audit experience, PEF or LCA methodology and practice, and knowledge of relevant technologies, processes or other activities represented by the studied product(s). Table 8 presents the scoring system for each relevant competence and experience topic.

Unless otherwise specified in the context of the intended application, the reviewer's self-declaration based on the scoring system constitutes the minimum requirement.

Table 8: Scoring system for eligible reviewers/review teams

Topic		Criteria	Score (points) 0	1	2	3	4
Manda-tory criteria	Review, verification and audit practice						
		Years of experience[1]	0 – 2	3 – 4	5 – 8	9 – 14	> 14
		Number of reviews[2]	0 – 2	3 – 5	6 – 15	16 – 30	> 30
	LCA methodology and practice	**Years of experience**[3]	0 – 2	3 – 4	5 –8	9 – 14	> 14
		"Experiences" of participation in LCA work	0 – 4	5 – 8	9 – 15	16 – 30	> 30
	Technologies or other activities relevant to the PEF study	**Years of experience in private sector**[4]	0 – 2 (within the past 10 years)	3 – 5 (within the past 10 years)	6 – 10 (within the past 20 years)	11 – 20	> 20
		Years of experience in public sector[5]	0 – 2 (within the past 10 years)	3 – 5 (within the past 10 years)	6 –10 (within the past 20 years)	11 – 20	> 20
Other[6]	Review, verification and audit practice	Optional scores relating to audit	▪ 2 points: Accreditation as third party reviewer for at least one EPD Scheme, ISO 14001, or other EMS. ▪ 1 point: Attended courses on environmental audits (at least 40 hours). ▪ 1 point: Chair of at least one review panel (for LCA studies or other environmental applications). ▪ 1 point: Qualified trainer in environmental audit course.				

Notes:

1. Years of experience in the field of environmental review and auditing.

2. Number of reviews for ISO 14040/14044 compliance, ISO 14025 compliance (Environmental Product Declarations (EPD)), or LCI datasets.
3. Years of experience in the field of LCA work, starting from University degree.
4. Years of experience in a sector related to the studied product(s). The qualification of knowledge about technologies or other activities is assigned according to the classification of NACE codes (*Regulation (EC) No 1893/2006 of the European Parliament and of the Council of 20 December 2006 establishing the statistical classification of economic activities - NACE Revision 2*). Equivalent classifications of other international organisations can also be used. Experience gained with technologies or processes in any sub-sector are considered valid for the whole sector.
5. Years of experience in the public sector, e.g. research centre, university, government institution relating to the studied product(s)

   * Candidate must calculate years of experience based on employment contracts. For example, Prof. A works in University B part-time from Jan 2005 until Dec 2010 and part-time at a refinery company. Prof. A can count years of experience in the private sector as 3 years and 3 years for public sector (university).
6. The additional scores are complementary.

REQUIREMENT FOR PEF STUDIES

A critical review of the PEF study shall be conducted as per the requirements of the intended application. Unless otherwise specified, the minimum necessary score to qualify as a reviewer or a review team is six points, including at least one point for each of the three mandatory criteria (i.e. verification and audit practice, LCA methodology and practice, and knowledge of technologies or other activities relevant to the PEF study). Score points per criteria shall be achieved by individuals, while score points may be summed across criteria at the team level. Reviewers or review teams shall provide a self-declaration of their qualifications, stating how many points they achieved for each criterion and the total points achieved. This self-declaration shall form part of the PEF report.

10. Acronyms and Abbreviations

ADEME	Agence de l'Environnement et de la Maîtrise de l'Energie
B2B	Business to Business
B2C	Business to Consumer
BSI	British Standards Institution
CF	Characterisation Factor
CFCs	Chlorofluorocarbons
CPA	Classification of Product Activity
DQR	Data Quality Rating
EIA	Environmental Impact Assessments
ELCD	European Reference Life Cycle Database
EF	Environmental Footprint
EMAS	Eco-Management and Audit Schemes
EMS	Environmental Management Schemes
EoL	End-of-Life
EPD	Environmental Product Declaration
GHG	Greenhouse Gas
GRI	Global Reporting Initiative
ILCD	International Reference Life Cycle Data System
IPCC	Intergovernmental Panel on Climate Change
ISIC	International Standard Industrial Classification
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature and Natural Resources
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory

LCIA	Life Cycle Impact Assessment
LCT	Life Cycle Thinking
NACE	Nomenclature Générale des Activités Economiques dans les Communautés Européennes
OEF	Organisation Environmental Footprint
PAS	Publicly Available Specification
PCR	Product Category Rule
PEFCR	Product Environmental Footprint Category Rule
WRI	World Resources Institute
WBCSD	World Business Council for Sustainable Development

11. Glossary

Additional Environmental Information – EF impact categories and other environmental indicators that are calculated and communicated alongside PEF results.

Acidification – EF impact category that addresses impacts due to acidifying substances in the environment. Emissions of NO_x, NH_3 and SO_x lead to releases of hydrogen ions (H^+) when the gases are mineralised. The protons contribute to the acidification of soils and water when they are released in areas where the buffering capacity is low, resulting in forest decline and lake acidification.

Allocation – An approach to solving multi-functionality problems. It refers to "*partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems*" (ISO 14040:2006).

Attributional – Refers to process-based modelling intended to provide a static representation of average conditions, excluding market-mediated effects.

Average Data – Refers to a production-weighted average of specific data.

Background processes – Refers to those processes in the product life cycle for which no direct access to information is possible. For example, most of the upstream life-cycle processes and generally all processes further downstream will be considered part of the background processes.

Business to Business (B2B) – Describes transactions between businesses, such as between a manufacturer and a wholesaler, or between a wholesaler and a retailer.

Business to Consumers (B2C) – Describes transactions between business and consumers, such as between retailers and consumers. According to ISO 14025:2006, a consumer is defined as "*an individual member of the general public purchasing or using goods, property or services for private purposes*".

Characterisation – Calculation of the magnitude of the contribution of each classified input/output to their respective EF impact categories, and aggregation of contributions within each category. This requires a linear multiplication of the inventory data with *characterisation factors* for each substance and EF impact category of concern. For example, with respect to the EF impact category "climate change", CO_2 is chosen as the reference substance and kg CO_2-equivalents as the reference unit.

Characterisation factor – Factor derived from a characterisation model which is applied to convert an assigned Resource Use and Emissions Profile result to the common unit of the EF impact category indicator (based on ISO 14040:2006).

Classification – Assigning the material/energy inputs and outputs tabulated in the Resource and Emissions Profile to EF impact categories according to each substance's potential to contribute to each of the EF impact categories considered.

Co-function - Any of two or more functions resulting from the same unit process or product system.

Comparative Assertion – An environmental claim regarding the superiority or equivalence of products, based on the results of a PEF study and supporting PEFCRs (based on ISO 14040:2006).

Comparison – A comparison, not including a comparative assertion, (graphic or otherwise) of two or more products regarding the results of their PEF, taking into account their PEFCRs, not including a comparative assertion.

Co-product – Any of two or more products resulting from the same unit process or product system (ISO 14040:2006).

Cradle to Gate – An assessment of a partial product supply chain, from the extraction of raw materials (cradle) up to the manufacturer's "gate". The distribution, storage, use stage and end-of-life stages of the supply chain are omitted.

Cradle to Grave – An assessment of a product's life cycle including raw material extraction, processing, distribution, storage, use, and disposal or recycling stages. All relevant inputs and outputs are considered for all of the stages of the life cycle.

Critical review – Process intended to ensure consistency between a PEF study and the principles and requirements of this PEF Guide and PEFCRs (if available) (based on ISO 14040:2006).

Data Quality – Characteristics of data that relate to their ability to satisfy stated requirements (ISO 14040:2006). Data quality covers various aspects, such as technological, geographical and time-related representativeness, as well as completeness and precision of the inventory data.

Direct Land Use Changes (dLUC) – The transformation from one land use type into another, which takes place in a unique land area and does not lead to a change in another system.

Directly attributable – Refers to a process, activity or impact occurring within the defined Organisational Boundary.

Downstream – Occurring along a product supply chain after the point of referral.

Ecological Footprint – Refers to "*the area of productive land and water ecosystems required to produce the resources that the population consumes and assimilate the wastes that the population produces, wherever on Earth the land and water is located*" (Wackernagel and Rees, 1996). According to the PEF Guide the environmental footprint is not equal to the ecological footprint of Wackernagel and Rees; the main differences are highlighted in Annex X.

Ecotoxicity – Environmental footprint impact category that addresses the toxic impacts on an ecosystem, which damage individual species and change the structure and function of the ecosystem. Ecotoxicity is a result of a variety of different toxicological mechanisms caused by the release of substances with a direct effect on the health of the ecosystem.

Elementary flows – In the Resource Use and Emissions Profile, elementary flows include "*material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation"* (ISO 14040, 3.12). Elementary flows include, for example, resources taken from nature or emissions into air, water, soil that are directly linked to the characterisation factors of the EF impact categories.

Environmental aspect – An element of an organisation's activities or products that has or can have an impact on the environment (EMAS regulation).

Environmental Footprint (EF) Impact Assessment – Phase of the PEF analysis aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product (based on ISO 14044:2006). The EF impact assessment methods

provide impact characterisation factors for elementary flows to aggregate the impact to a limited number of midpoint and/or damage indicators.

Environmental Footprint (EF) Impact Assessment Method – Protocol for quantitative translation of Resource Use and Emissions Profile data into contributions to an environmental impact of concern.

Environmental Footprint (EF) Impact Category – Class of resource use or environmental impact to which the Resource Use and Emissions Profile data are related.

Environmental Footprint (EF) impact category indicator – Quantifiable representation of an EF impact category (based on ISO 14000:2006).

Environmental impact – Any change to the environment, whether adverse or beneficial, that wholly or partially results from an organisation's activities, products or services (EMAS regulation).

Environmental mechanism – System of physical, chemical and biological processes for a given EF impact category linking the Resource Use and Emissions Profile results to EF category indicators (based on ISO 14040:2006).

Eutrophication – Nutrients (mainly nitrogen and phosphorus) from sewage outfalls and fertilised farmland accelerate the growth of algae and other vegetation in water. The degradation of organic material consumes oxygen resulting in oxygen deficiency and, in some cases, fish death. Eutrophication translates the quantity of substances emitted into a common measure expressed as the oxygen required for the degradation of dead biomass.

Extrapolated Data – Refers to data from a given process that is used to represent a similar process for which data is not available, on the assumption that it is reasonably representative.

Flow diagram – Schematic representation of the flows occurring during one or more process stages within the life cycle of the product being assessed.

Foreground Processes – Refer to those processes in the product life cycle for which direct access to information is available. For example, the producer's site and other processes operated by the producer or its contractors (e.g. goods transport, head-office services, etc.) belong to the foreground processes.

Gate to Gate – A partial assessment looking only at the processes carried out on a product within a specific organisation or site.

Gate to Grave – An assessment including only the distribution, storage, use, and disposal or recycling stages of a product.

Generic Data – Refers to data that is not directly collected, measured, or estimated, but rather sourced from a third-party life-cycle-inventory database or other source that complies with the data quality requirements of the PEF method.

Global Warming Potential – Capacity of a greenhouse gas to influence radiative forcing, expressed in terms of a reference substance (for example, CO_2-equivalent units) and specified time horizon **(**e.g. GWP 20, GWP 100, GWP 500, for 20, 100, and 500 years respectively**).** It relates to the capacity to influence changes in the global average surface-air temperature and subsequent change in various climate parameters and their effects, such as storm frequency and intensity, rainfall intensity and frequency of flooding, etc.

Human Toxicity – cancer – EF impact category that accounts for the adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin insofar as they are related to cancer.

Human Toxicity - non cancer – EF impact category that accounts for the adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin insofar as they are related to non-cancer effects that are not caused by particulate matter/respiratory inorganics or ionising radiation.

Indirect Land Use Changes (iLUC) – Occur when a demand for a certain land use leads to changes, outside the system boundaries, i.e. in other land use types. These indirect effects can be mainly accessed by means of economic modelling of the demand for land or by modelling the relocation of activities on a global scale. The main drawbacks of such models are their reliance on trends, which might not reflect future developments. They are commonly used as the basis for political decisions.

Input – Product, material or energy flow that enters a unit process. Products and materials include raw materials, intermediate products and co-products (ISO 14040:2006).

Intermediate product – Output form a unit process that is input to other unit processes that require further transformation within the system (ISO 14040:2006).

Ionising Radiation, human health – EF impact category that accounts for the adverse health effects on human health caused by radioactive releases.

Land Use – EF impact category related to use (occupation) and conversion (transformation) of land area by activities such as agriculture, roads, housing, mining, etc. Land occupation considers the effects of the land use, the amount of area involved and the duration of its occupation (changes in quality multiplied by area and duration). Land transformation considers the extent of changes in land properties and the area affected (changes in quality multiplied by the area).

Life cycle – Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal (ISO 14040:2006).

Life-Cycle Approach – Takes into consideration the spectrum of resource flows and environmental interventions associated with a product from a supply-chain perspective, including all stages from raw material acquisition through processing, distribution, use, and end-of-life processes, and all relevant related environmental impacts (instead of focusing on a single issue).

Life-Cycle Assessment (LCA) – Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14040:2006).

Life-Cycle Impact Assessment (LCIA) – Phase of life cycle assessment that aims at understanding and evaluating the magnitude and significance of the potential environmental impacts for a system throughout the life cycle (ISO 14040:2006). The LCIA methods used provide impact characterisation factors for elementary flows to aggregate the impact to a limited number of midpoint and/or damage indicators.

Loading rate – Ratio or capacity (e.g. mass or volume) that a vehicle carries per trip.

Multi-functionality – If a process or facility provides more than one function, i.e. it delivers several goods and/or services ("co-products"), it is “multifunctional”. In these situations, all inputs and emissions linked to the process must be partitioned between the product of interest and the other co-products in a principled manner.

Non-elementary (or complex) flows – In the Resource Use and Emissions Profile, non-elementary flows include all the inputs (e.g. electricity, materials, transport processes) and outputs (e.g. waste, by-products) in a system that need further modelling efforts to be transformed into elementary flows.

Normalisation – After the characterisation step, normalisation is an optional step in which the EF impact assessment results are multiplied by normalisation factors that represent the overall inventory of a reference unit (e.g. a whole country or an average citizen). Normalised EF impact assessment results express the relative shares of the impacts of the analysed system in terms of the total contributions to each impact category per reference unit. When displaying the normalised EF impact assessment results of the different impact topics next to each other, it becomes evident which impact categories are affected most and least by the analysed system. Normalised EF impact assessment results reflect only the contribution of the analysed system to the total impact potential, not the severity/relevance of the respective total impact. Normalised results are dimensionless, but not additive.

Output – Product, material or energy flow that leaves a unit process. Products and materials include raw materials, intermediate products, co-products and releases (ISO 14040:2006).

Ozone Depletion – EF impact category that accounts for the degradation of stratospheric ozone due to emissions of ozone-depleting substances, for example long-lived chlorine and bromine containing gases (e.g. CFCs, HCFCs, Halons).

Particulate Matter/Respiratory Inorganics – EF impact category that accounts for the adverse health effects on human health caused by emissions of Particulate Matter (PM) and its precursors (NO_x, SO_x, NH_3)

Photochemical Ozone Formation – EF impact category that accounts for the formation of ozone at the ground level of the troposphere caused by photochemical oxidation of Volatile Organic Compounds (VOCs) and carbon monoxide (CO) in the presence of nitrogen oxides (NO_x) and sunlight. High concentrations of ground-level tropospheric ozone damage vegetation, human respiratory tracts and manmade materials through reaction with organic materials.

Product – Any goods or services (ISO 14040:2006).

Product category – Group of products that can fulfil equivalent functions (ISO 14025:2006).

Product Category Rules (PCR) – Set of specific rules, requirements and guidelines for developing Type III environmental declarations for one or more product categories (ISO 14025:2006).

Product Environmental Footprint Category Rules (PEFCRs) – Are product-type-specific, life-cycle-based rules that complement general methodological guidance for PEF studies by providing further specification at the level of a specific product category. PEFCRs can help to shift the focus of the PEF study towards those aspects and parameters that matter the most, and hence contribute to increased relevance, reproducibility and consistency.

Product flow – Products entering from or leaving to another product system (ISO 14040:2006).

Product system – Collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product (ISO 14040:2006).

Raw material – Primary or secondary material that is used to produce a product (ISO 14040:2006).

Reference Flow – Measure of the outputs from processes in a given product system required to fulfil the function expressed by the unit of analysis (based on ISO 14040:2006).

Releases – Emissions to air and discharges to water and soil (ISO 14040:2006).

Resource Depletion – EF impact category that addresses use of natural resources, either renewable or non-renewable, biotic or abiotic.

Resource Use and Emissions Profile – Refers to the inventory of data collected to represent the inputs and outputs associated with each stage of the product supply chain being studied. The compilation of the Resource Use and Emissions Profile is completed when non-elementary (i.e. complex) flows are transformed into elementary flows.

Resource Use and Emissions Profile results – Outcome of a Resource Use and Emissions Profile that catalogues the flows crossing the system boundary and provides the starting point for the EF impact assessment.

Sensitivity analysis – Systematic procedures for estimating the effects of the choices made regarding methods and data on the results of a PEF study (based on ISO 14040: 2006).

Soil Organic Matter (SOM) – Is the measure of the content of organic material in soil. This derives from plants and animals and comprises all of the organic matter in the soil exclusive of the matter that has not decayed.

Specific Data – Refers to directly measured or collected data representative of activities at a specific facility or set of facilities. Synonymous with “primary data.”

Subdivision – Subdivision refers to disaggregating multifunctional processes or facilities to isolate the input flows directly associated with each process or facility output. The process is investigated to see whether it can be subdivided. Where subdivision is possible, inventory data should be collected only for those unit processes directly attributable to the products/services of concern.

System Boundary – Definition of aspects included or excluded from the study. For example, for a “cradle-to-grave” EF analysis, the system boundary should include all activities from the extraction of raw materials through the processing, distribution, storage, use, and disposal or recycling stages.

System boundary diagram – Graphic representation of the system boundary defined for the PEF study.

Type III environmental declaration – An environmental declaration providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information (ISO 14025:2006). The predetermined parameters are based on the ISO 14040 series of standards, which is made up of ISO 14040 and ISO 14044.

Uncertainty analysis – Procedure to assess the uncertainty introduced into the results of a PEF study due to data variability and choice-related uncertainty.

Unit of Analysis – The unit of analysis defines the qualitative and quantitative aspects of the function(s) and/or service(s) provided by the product being evaluated; the unit of analysis definition answers the questions “what?”, “how much?”, “how well?”, and “for how long?”

Unit process – Smallest element considered in the Resource Use and Emissions Profile for which input and output data are quantified (based on ISO 14040:2006).

Waste – Substances or objects which the holder intends or is required to dispose of (ISO 14040:2006).

Weighting – Weighting is an additional, but not mandatory, step that may support the interpretation and communication of the results of the analysis. PEF results are multiplied by a set of weighting factors, which reflect the perceived relative importance of the impact categories considered. Weighted EF results can be directly compared across impact categories, and also summed across impact categories to obtain a single-

value overall impact indicator. Weighting requires making value judgements as to the respective importance of the EF impact categories considered. These judgements may be based on expert opinion, social science methods, cultural/political viewpoints, or economic considerations.

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Annex I: Summary of Key Mandatory Requirements for Product Environmental Footprint and for Developing Product Footprint Category Rules

The following table provides a summary that includes all mandatory ("shall") requirements for the PEF, as well as all ("shall", "should" and "may") of the additional requirements for developing of PEFCRs. These are extensively explained throughout this Guide, as indicated in the left-hand column of the table.

Table 9: Summary of Key Mandatory requirements for PEF studies and additional requirements for developing PEFCRs

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
1	General Approach	A PEF study shall be based on a life-cycle approach.	
1.1	Principles	Users of this Guide shall observe the following principles in conducting a PEF study: 1. Relevance; 2. Completeness; 3. Consistency; 4. Accuracy; 5. Transparency.	Principles for PEFCRs: 1. Relationship with the PEF Guide; 2. Involvement of selected interested parties; 3. Striving for comparability.
2.1	Role of PEFCRs	In the absence of PEFCRs, the key areas that would be covered in PEFCRs (as listed in this PEF Guide) shall be specified, justified and explicitly reported in the PEF study.	
2.2	Relation with existing PCRs		PEFCRs should, to the extent possible and recognising the different application contexts, be in conformity with existing international Product Category Rule (PCR) guidance documents.
2.3	CPA-based PEFCR structure		PEFCRs shall be based at a minimum on a two-digit CPA code division (default option). However, PEFCRs may allow for (justified) deviations (e.g. allow for three-digits). For example, more than two-digits are

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
			necessary when addressing the complexity of the sector. Where multiple production routes for similar products are defined using alternative CPAs, the PEFCR shall accommodate all such CPAs.
3.1	Goal definition	Goal definition for a PEF study shall include: • Intended application(s); • Reasons for carrying out the study and decision context; • Target audience; • Whether comparisons and/or comparative assertions are to be disclosed to the public; • Commissioner of the study; • Review procedure (if applicable).	The PEFCR shall specify the review requirements for a PEF study.
4.1	Scope definition	The scope definition for a PEF study shall be in line with the defined goals of the study and shall include: • Unit of analysis and reference flow; • System boundaries; • EF impact categories; • Assumptions and limitations.	
4.2	Unit of analysis and reference flow	The unit of analysis for a PEF study shall be defined according to the following aspects: • The function(s)/service(s) provided: “what”; • The magnitude of the function or service: “how much”; • The expected level of quality: “how well”;	The PEFCR shall specify the unit(s) of analysis

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
		• The duration/life time of the product: "how long"; • The NACE code(s). An appropriate reference flow shall be determined in relation to the unit of analysis. The quantitative input and output data collected in support of the analysis shall be calculated in relation to this flow.	
4.3	System boundaries	The system boundary shall be defined following general supply-chain logic, including all stages from raw material extraction through processing, production, distribution, storage, use stage and end-of-life treatment of the product (i.e. cradle-to-grave), as appropriate to the intended application of the study. The system boundaries shall include all processes linked to the product supply chain relative to the unit of analysis. The processes included in the system boundaries shall be divided into foreground processes (i.e. core processes in the product life cycle for which direct access to information is available) and background processes (i.e. those processes in the product life cycle for which no direct access to information is possible).	The PEFCR shall specify the system boundaries for product category PEF studies, including specification of relevant life-cycle stages and processes. Any deviation from the default cradle-to-grave approach shall be explicitly specified and justified, e.g. exclusion of the unknown use-stage or end-of-life of intermediate products. The PEFCR shall specify downstream scenarios so as to ensure comparability and consistency among PEF studies.
4.3	Offsets	Offsets shall not be included in the PEF study. However, they may be reported separately as "additional environmental information".	
4.4	Selection of EF impact categories and methods	For a PEF study, all of the specified default EF impact categories and associated specified EF impact assessment models shall be applied. Any exclusion shall be explicitly documented, justified, reported in the PEF report and supported by appropriate documents. The influence of any exclusion on the final	PEFCRs shall specify and justify any exclusion of the default EF impact categories, especially those related to the aspects of comparability.

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
		results, especially related to limitations in terms of comparability with other PEF studies, shall be discussed in the interpretation phase and reported. Such exclusions are subject to review.	
4.5	Selecting additional environmental information	If the default set of EF impact categories or the default impact assessment models do not properly cover the potential environmental impacts of the product being evaluated, all related relevant (qualitative/quantitative) environmental aspects shall be additionally included under "additional environmental information". These shall, however, not substitute the mandatory assessment models of the default EF impact categories. The supporting models of these additional categories shall be clearly referenced and documented with the corresponding indicators. Additional environmental information shall be: • Based on information that is substantiated and has been reviewed or verified, in accordance with the requirements of ISO 14020 and Clause 5 of ISO 14021:1999; • Specific, accurate and not misleading; • Relevant to the particular product category. Emissions made directly into marine water shall be included in the additional environmental information (at inventory level). If additional environmental information is used to support the interpretation phase of a PEF study, then all data needed to produce such information shall meet the	The PEFCR shall specify and justify additional environmental information that is to be included in the PEF study. Such additional information shall be reported separately from the life-cycle based PEF results, with all methods and assumptions clearly documented. Additional environmental information may be quantitative and/or qualitative. Additional environmental information may include (non-exhaustive list): o Other relevant environmental impacts for the product category; o Other relevant technical parameters that may be used to assess the product under study and allow for comparisons with other products of the overall product-system efficiency. These technical parameters may refer to, for example, the use of renewable versus non-renewable energy, the use of renewable versus non-renewable fuels, the use of secondary materials, the use of fresh water resources, or the disposal of hazardous versus non-hazardous waste types; o Other relevant approaches for conducting characterisation of the flows from the Resource Use and Emissions Profile, when characterisation factors (CFs) in the default method are not available for certain flows (e.g. groups of chemicals); o Environmental indicators or product responsibility indicators (as per the Global Reporting Initiative (GRI)); o Life cycle energy consumption by primary energy source,

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
		same quality requirements established for the data used to calculate the PEF results. Additional environmental information shall only be related to environmental issues. Information and instructions, e.g. product safety sheets that are not related to the environmental performance of the product, shall not be part of a PEF. Similarly, information related to legal requirements shall not be included.	separately accounting for "renewable" energy use; o Direct energy consumption by primary energy source, separately accounting for "renewable" energy use for facility gate; o For gate-to-gate phases, number of IUCN Red List species and national conservation list species with habitats in areas affected by operations, by level of extinction risk; o Description of significant impacts of activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas; o Total weight of waste by type and disposal method; o Weight of transported, imported, exported, or treated waste deemed hazardous under the terms of the Basel Convention Annexes I, II, III, and VIII, and percentage of transported waste shipped internationally.
4.6	Assumptions/limitations	All limitations and assumptions shall be transparently reported.	The PEFCRs shall report product category-specific limitations and define the assumptions necessary to overcome the limitations.
5.1	Resource Use and Emissions Profile	All resource use and emissions associated with the life-cycle stages included in the defined system boundaries shall be included in the Resource Use and Emissions Profile. The flows shall be grouped into "elementary flows" and "non-elementary (i.e. complex) flows". All non-elementary flows in the Resource Use and Emissions Profile shall then be transformed into elementary flows.	
5.2	Resource Use and Emissions Profile – Screening step	If a screening step is conducted (highly recommended), readily available specific and/or generic data shall be used fulfilling the data quality requirements as defined in section 5.6. All processes and activities to be considered	The PEFCR shall specify processes to be included, as well as associated data quality and review requirements, which may exceed those of this PEF Guide. It shall also specify for which processes specific data are required, for which the use of generic data is either

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
		in the Resource Use and Emissions Profile shall be included in the screening step. Any exclusion of supply-chain stages shall be explicitly justified and submitted to the review process, and their influence on the final results discussed. For supply-chain stages for which a quantitative EF impact assessment is not intended, the screening step shall refer to existing literature and other sources in order to develop qualitative descriptions of potentially environmentally significant processes. Such qualitative descriptions shall be included in the additional environmental information.	permissible or required.
5.4	Resource Use and Emissions Profile - Data	All resource use and emissions associated with the life-cycle stages included in the defined system boundaries shall be included in the Resource Use and Emissions Profile. The following elements shall be considered for inclusion in the Resource Use and Emissions Profile: • Raw material acquisition and pre-processing; • Capital goods: linear depreciation shall be used; • Production; • Product distribution and storage; • Use stage; • Logistics; • End-of-life.	The PEFCRs should provide one or more examples for compiling the Resource Use and Emissions Profile, including specifications with respect to: • Substance lists for activities/processes included; • Units; • Nomenclature for elementary flows. These may apply to one or more supply-chain stages, processes, or activities, for the purpose of ensuring standardised data collection and reporting. The PEFCR may specify more stringent data requirements for key upstream, gate-to-gate or downstream stages than those defined in this PEF Guide. For modelling processes/activities within the core module (i.e. gate-to-gate stage), the PEFCRs shall also specify: • Processes/activities included; • Specifications for compiling data for key processes, including averaging data across facilities; • Any site-specific data required for reporting as “additional environmental information”;

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
			• Specific data quality requirements, e.g. for measuring specific activity data. If the PEFCRs also require deviations from the default cradle-to-grave system boundary (e.g. if a PEFCR prescribes using cradle-to-gate boundary), the PEFCRs shall specify how material/energy balances in the Resource Use and Emissions Profile shall be accounted for.
5.4.5	Use stage	Where no method for determining the use stage of products has been established in accordance with the techniques specified in this Guide, the approach taken in determining the use stage of products shall be established by the organisation carrying out the study. The actual usage pattern may, however, differ from those recommended and should be used if this information is available. Relevant influences on other systems due to the use of the products shall be included. Documentation of methods and assumptions shall be provided. All relevant assumptions for the use stage shall be documented.	The PEFCRs shall specify: • The use-stage scenarios to be included in the study, if any; • The time span to be considered for the use stage.
5.4.6	Logistics	Transport parameters that shall be taken into account are: transport type, vehicle type and fuel consumption, loading rate, number of empty returns when applicable and relevant, transport distance, allocation for goods transport based on load-limiting factor (i.e. mass for high density products and volume for low density products) and fuel production. The impacts due to transport shall be expressed in the default reference units, i.e. tkm for goods and person-km for passenger transport. Any deviation from these	The PEFCRs shall specify transport, distribution and storage scenarios to be included in the study, if any.

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
		default reference units shall be reported and justified. The environmental impact due to transport shall be calculated by multiplying the impact per reference unit for each of the vehicle types by a) for goods: the distance and load and b) for persons: the distance and number of persons based on the defined transport scenarios.	
5.4.7	End-of-life stage	Waste flows arising from processes included in the system boundaries shall be modelled to the level of elementary flows.	The end-of-life scenarios, if any, shall be defined in the PEFCRs. These scenarios shall be based on current (year of analysis) practice, technology and data.
5.4.8	Electricity use	For electricity from the grid consumed upstream or within the defined PEF boundary, supplier-specific data shall be used if available. If supplier-specific data is not available, country-specific consumption-mix data shall be used of the country in which the life cycle stages occur. For electricity consumed during the use stage of products, the energy mix shall reflect ratios of sales between countries or regions. Where such data are not available, the average EU consumption mix, or otherwise most representative mix, shall be used. It shall be guaranteed that the renewable electricity (and associated impacts) from the grid consumed upstream or within the defined PEF boundary is not double counted. A statement of the supplier shall be included as an annex to the PEF report, guaranteeing that the electricity supplied is effectively generated using renewable sources and is not sold to any other organisation.	
5.4.9	Biogenic carbon removals and emissions	Removals and emissions of biogenic carbon sources shall be kept separated in the Resource Use and Emissions	

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
		Profile.	
5.4.9	Direct and indirect land use change (impact for climate change)	Greenhouse gas emissions from direct land use change shall be allocated to goods/services for 20 years after the land use change occurs using the IPCC default values. For details, see Annex VI. Greenhouse gas emissions from indirect land use change shall not be included.	
5.4.9	Renewable energy generation	Credits associated with renewable energy generated by the system boundary shall be calculated with respect to the corrected (i.e. by subtracting the externally provided amount of renewable energy) average, country-level consumption mix of the country to which the energy is provided. Where such data is not available, the corrected average EU consumption mix, or otherwise most representative mix shall be used. If no data are available on the calculation of corrected mixes, the uncorrected average mixes shall be used. It shall be transparently reported which energy mixes are assumed for the calculation of the benefits and whether or not these have been corrected.	
5.4.9	Temporary (carbon) storage and delayed emissions	Credits associated with temporary (carbon) storage or delayed emissions shall not be considered in the calculation of the default EF impact categories. However, these may be included as “additional environmental information”. Moreover, these shall be included under “additional environmental information” if specified in a supporting PEFCR.	
5.5	Nomenclature	All relevant resource use and emissions associated with the life-cycle stages included in the defined system boundaries shall be documented using the International Life Cycle Data System (ILCD) nomenclature and properties, as described in Annex IV. If nomenclature and properties for a given flow are not available in the ILCD, the practitioner shall create an appropriate	

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
		nomenclature and document the flow properties.	
5.6	Data Quality requirements	Data quality requirements shall be met by PEF studies intended for external communication, i.e. B2B and B2C. For PEF studies (claiming to be in line with this Guide) intended for in-house applications, the specified data quality requirements should be met (i.e. are recommended), but are not mandatory. Any deviations from the requirements shall be documented. Data quality requirements apply to both specific and generic data. The following six criteria shall be adopted for a semi-quantitative assessment of data quality in PEF studies: technological representativeness, geographical representativeness, time-related representativeness, completeness, parameter uncertainty and methodological appropriateness. In the optional screening step a minimum "fair" quality data rating is required for data contributing to at least 90% of the impact estimated for each EF impact category, as assessed via a qualitative expert judgement. In the final Resource Use and Emissions Profile, for the processes or activities accounting for at least 70% of contributions to each EF impact category, both specific and generic data shall achieve at least an overall "good quality" level. A semi-quantitative assessment of data quality shall be performed and reported for these processes. At least 2/3 of the remaining 30% (i.e. 20% to	PEFCRs shall provide further guidance on data-quality assessment scoring for the considered product category with respect to time, geographical and technological representativeness, e.g. it shall specify which data quality score related to time representativeness should be assigned to a dataset representing a given year. PEFCRs may specify additional criteria for the assessment of data quality (compared to default criteria). PEFCRs may specify more stringent data quality requirements, if appropriate for the product category considered. These may include: • Gate-to-gate activities/processes; • Upstream or downstream phases; • Key supply-chain activities for the product category; • Key EF impact categories for the product category.

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
		30%) shall be modelled with at least "fair quality" data. Data of less than fair quality rating shall not account for more than 10% contributions to each EF impact category. The data quality requirements for technological, geographical and time-related representativeness shall be subject to review as part of the PEF study. The data quality requirements related to completeness, methodological appropriateness and consistency, and parameter uncertainty should be met by sourcing generic data exclusively from data sources that comply with the requirements of the PEF Guide. With respect to the data quality criterion of "methodological appropriateness and consistency", the requirements as defined in Table 6 shall apply until the end of 2015. From 2016, full compliance with the PEF methodology will be required. The data quality assessment of generic data shall be conducted at the level of the input flows (e.g. purchased paper used in a printing office) while the data quality assessment of specific data shall be conducted at the level of an individual process or aggregated process, or at the level of individual input flows.	
5.7	Specific data collection	Specific data shall be obtained for all foreground processes and for background processes, where appropriate. However, if generic data are more representative or appropriate than specific data for foreground processes (to be reported and justified),	PEFCRs shall: 1. Specify for which processes specific data shall be collected. 2. Specify the requirements for collection of specific data.

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
		generic data shall also be used for the foreground processes. It should be noted that emission factors may be derived from generic data subject to data quality requirements.	3. Define the data collection requirements for the following aspects for each site: • Target stage(s) and the data collection coverage; • Location of data collection (domestically, internationally, representative factories, and so on); • Term of data collection (year, season, month, etc.); • When the location or term of data collection must be limited to a certain range, provide a justification and show that the collected data will serve as sufficient samples.
5.8	Generic data collection	When available, sector-specific generic data shall be used instead of multi-sector generic data. All generic data shall fulfil the data quality requirements specified in this document. The sources of the data used shall be clearly documented and reported in the PEF report. Generic data (provided they fulfil the data quality requirements specified in this PEF Guide) should, where available, be sourced from: • Data developed in line with the requirements of the relevant PEFCRs; • Data developed in line with the requirements for PEF studies; • International Reference Life Cycle Data System (ILCD) Data Network (giving preference to datasets that are fully compliant with the ILCD	The PEFCR shall specify: • Where the use of generic data is permitted as an approximation for a substance for which specific data is not available; • The level of required similarities between the actual substance and the generic substance; • The combination of more than one generic dataset, if necessary.

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
		Data Network over those that are only entry-level compliant); • ELCD database.	
5.9	Dealing with Data Gaps	Any data gaps shall be filled using best available generic or extrapolated data. The contribution of such data (including gaps in generic data) shall not account for more than 10% of the overall contribution to each EF impact category considered. This is reflected in the data quality requirements, according to which 10% of the data can be chosen from the best available data (without any further data quality requirements).	The PEFCR shall specify potential data gaps and provide detailed guidance for filling these gaps.
5.10	Handling Multi functionality	The following PEF multi-functionality decision hierarchy shall be applied for resolving all multi-functionality problems: (1) subdivision or system expansion; (2) allocation based on a relevant underlying physical relationship (including direct substitution, or some relevant underlying physical relationship); (3) allocation based on some other relationship (including indirect substitution, or some other relevant underlying relationship). All choices made in this context shall be reported and justified with respect to the overarching goal of ensuring physically representative, environmentally relevant results. For multi-functionality of products in recycling or energy recovery situations, the equation described in Annex V shall be applied. The above decision hierarchy also applies for end-of-life multi-functionality.	The PEFCR shall further specify multi-functionality solutions for application within the defined system boundaries and, where appropriate, for upstream and downstream stages. If feasible/appropriate, then PEFCR may further provide specific factors to be used in the case of allocation solutions. All such multi-functionality solutions specified in the PEFCR must be clearly justified with reference to the PEF multi-functionality solution hierarchy. Where sub-division is applied, the PEFCR shall specify which processes are to be sub-divided and the principles that such subdivision should adhere to. Where allocation by physical relationship is applied, the PEFCR shall specify the relevant underlying physical relationships to be considered, and establish the relevant allocation factors. Where allocation by some other relationship is applied, the PEFCR shall specify the relationship and establish the relevant allocation factors. For example, in the case of economic allocation, the PEFCR shall specify the rules for determining the economic values of co-products.

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
			For multi-functionality in end-of-life situations, the PEFCR shall specify how to calculate the different parts within the mandatory formula provided.
6.1	Environmental Footprint Impact Assessment	EF impact assessment shall include a classification and characterisation of the Product Environmental Footprint flows.	
6.1.1	Classification	All inputs/outputs inventoried during the compilation of the Resource Use and Emissions Profile shall be assigned to the EF impact categories to which they contribute ("classification") using the classification data available at: http://lct.jrc.ec.europa.eu/assessment/projects. As part of the classification of the Resource Use and Emissions Profile, data should be expressed in terms of constituent substances for which characterisation factors are available.	
6.1.2	Characterisation	All classified inputs/outputs in each EF impact category shall be assigned characterisation factors representing the contribution per input/output unit to the category, using the specified characterisation factors, available at http://lct.jrc.ec.europa.eu/assessment/projects EF impact assessment results shall subsequently be calculated for each EF impact category by multiplying the amount of each input/output by its characterisation factor and summing contributions of all inputs/outputs within each category to a single measure expressed in terms of an appropriate reference unit. If characterisation factors (CFs) from the default method are not available for certain flows (e.g. a group of chemicals) of the Resource Use and Emissions Profile, then other approaches may be used for characterising these flows. In such circumstances, this shall be reported	

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
		under "additional environmental information". The characterisation models shall be scientifically and technically valid, and based upon distinct, identifiable environmental mechanisms or reproducible empirical observations.	
6.2.1	Normalisation (if applied)	Normalisation is not a required step for PEF studies. If normalisation is applied, the methods and results shall be reported under "additional environmental information", with all methods and assumption documented. Normalised results shall not be aggregated as this implicitly applies weighting. Results from the EF impact assessment prior to normalisation shall be reported alongside the normalised results.	
6.2.2	Weighting (if applied)	Weighting is not a required step for PEF studies. If weighting is applied, the methods and results shall be reported under "additional environmental information". Results of the EF impact assessment prior to weighting shall be reported alongside weighted results. The application of normalisation and weighting steps in PEF studies shall be consistent with the defined goals and scope of the study, including the intended applications.	
7.1	Interpretation of results	The interpretation phase shall include the following steps: "assessment of the robustness of the PEF model", "identification of hotspots", "estimation of uncertainty" and "conclusions, limitations and recommendations".	
7.2	Model robustness	The assessment of the PEF model robustness shall include an assessment of the extent to which methodological choices influence the results. These choices shall correspond to the requirements specified in	

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
		this PEF Guide and shall be appropriate to the context. Tools that should be used to assess the robustness of the PEF model are completeness checks, sensitivity checks and consistency checks.	
7.3	Identification of Hotspots	PEF results shall be evaluated to assess supply-chain hotspots/weak points on input/output, process, and supply-chain stage bases and to assess potential for improvements.	The PEFCR shall identify the most relevant EF impact categories for the sector. Normalisation and weighting may be used to achieve such prioritisation.
7.4	Estimation of Uncertainty	At least a qualitative description of the uncertainties of the final PEF results shall be provided for both choice-related uncertainties and uncertainties of inventory data, which gives an overall appreciation of the uncertainties of the PEF study results.	The PEFCR shall describe the uncertainties common to the product category and should identify the range in which results could be seen as not being significantly different in comparisons or comparative assertions.
7.5	Conclusions, Recommendations, and Limitations	Conclusions, recommendations and limitations shall be described in accordance with the defined goals and scope of the PEF study. PEF studies intended to support comparative assertions to be disclosed to the public (i.e. claims about the environmental superiority or equivalence of product compared to other product) shall be based both on this PEF Guide and related PEFCRs. Conclusions derived from the PEF study should include a summary of identified supply chain “hotspots” and the potential improvements associated with management interventions.	
8.2	Reporting	Any PEF study intended for external communications shall include a PEF study report, which shall provide a robust basis for assessing, tracking, and seeking to improve the environmental performance of the product over time. The PEF study report shall include, at a minimum, a Summary, a Main Report and an Annex. These shall contain all the elements specified in this	PEFCRs shall specify and justify any deviations from the default reporting requirements presented in chapter 8, as well as specify and justify any additional reporting requirements and/or differentiate reporting requirements depending on, e.g., the type of applications of the PEF study and the type of product being assessed. The PEFCRs shall specify whether the PEF results shall be reported separately for

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
		chapter. Any additional supporting information may also be included, for example a Confidential Report.	each of the selected life cycle stages.
9.1	Review	Any PEF study intended for external communication (e.g. B2B and B2C) shall be critically reviewed in order to assure that: • The methods used to carry out the PEF study are consistent with this PEF Guide; • The methods used to carry out the PEF study are scientifically and technically valid; • The data used are appropriate, reasonable and meet the defined data quality requirements; • The interpretation of results reflects the limitations identified; • The study report is transparent, accurate and consistent.	
9.2	Review type	Unless otherwise specified in relevant policy instruments, any study intended for external communication (e.g. B2B and B2C) shall be critically reviewed by at least one independent and qualified external reviewer (or review team.) A PEF study intended to support a comparative assertion to be disclosed to the public shall be based on relevant PEFCRs and critically reviewed by an independent panel of three qualified external reviewers. The type of review conducted should be informed by the goals and intended applications of the PEF study.	The PEFCR shall specify the review requirements for PEF studies intended to be used for comparative assertions to be disclosed to the public (e.g. whether a review by at least 3 independent qualified external reviewers is sufficient).
9.3	Reviewer Qualifications	A critical review of the PEF study shall be conducted as per the requirements of the intended application. Unless otherwise specified, the minimum necessary score to	

Chapter/section	Criteria	Requirements for PEF	Additional Requirements for Developing PEFCRs
		qualify as a reviewer or a review team is six points, including at least one point for each of the three mandatory criteria (i.e. verification and audit practice, LCA methodology and practice, and knowledge of technologies or other activities relevant to the PEF study). Score points per criteria shall be achieved by individuals, while score points may be summed across criteria at the team level. Reviewers or review teams shall provide a self-declaration of their qualifications, stating how many points they achieved for each criterion and the total points achieved. This self-declaration shall form part of the PEF Report.	

(INFORMATIVE)

Annex II: Data Management Plan (adapted from GHG Protocol Initiative[106])

If a data management plan is developed, the following steps should be undertaken and documented.

1. ***Establish a product accounting quality person/team.*** This person/team should be responsible for implementing and maintaining the data management plan, continually improving the quality of organisation inventories, and coordinating internal data exchanges and any external interactions (such as with relevant organisation accounting programs and reviewers).

2. ***Develop Data Management Plan and Checklist***. Development of the data management plan should begin before any data is collected to ensure that all relevant information about the inventory is documented as it proceeds. The plan should evolve over time as data collection and processes are refined. In the plan, the quality criteria and any evaluation/scoring systems are to be defined. The data management plan checklist outlines what components should be included in a data management plan and can be used as a guide for creating a plan or for pulling together existing documents to constitute the plan.

3. ***Perform data quality checks.*** Checks should be applied to all aspects of the inventory process, focusing on data quality, data handling, documentation, and calculation procedures. The defined quality criteria and scoring systems form the basis for the data quality checks.

4. ***Review of organisation inventory and reports.*** Selected independent external reviewers should review the study – ideally from the beginning.

5. ***Establish formal feedback loops to improve data collection, handling and documentation processes.*** Feedback loops are needed to improve the quality of the organisation inventory over time and to correct any errors or inconsistencies identified in the review process.

6. ***Establish reporting, documentation and archiving procedures.*** Establish record-keeping processes for which and how data should be stored, how they should be stored, what information should be reported as part of internal and external inventory reports, and what should be documented to support data collection and calculation methodologies. The process may also involve aligning or developing relevant database systems for record keeping.

The data management plan is likely to be an evolving document that is updated as data sources change, data handling procedures are refined, calculation methodologies improve, organisation inventory responsibilities change within an organisation, or the business objectives of the organisation inventory change.

[106] WRI and WBCSB - Annex 3 of the Greenhouse Gas Protocol's Corporate Value Chain (Scope 3) Accounting and Reporting Standard, 2011

(INFORMATIVE)

Annex III: Data collection checklist

A data collection template is useful for organising data collection activities and results while compiling the Resource Use and Emissions Profile. The following non-exhaustive checklist may be used as a starting point for data collection and organisation of a data collection template.

Key elements for data collection include:

- Introduction to the PEF study, including an overview of the objectives of data collection and the template/questionnaire employed;
- Information on the entity(ies) or person(s) responsible for measurement and data collection procedures;
- Description of the site where data is to be collected (for example, maximum and normal operation capacity, annual productive output, location, number of employees, etc.);
- Data sources and data quality rating;
- Date/year of data collection;
- Description of the product (and unit of analysis);
- Product system description and system boundary;
- Individual process-stage diagram ;
- Input and output per reference flow per unit.

Example: simplified data collection template

Technical overview

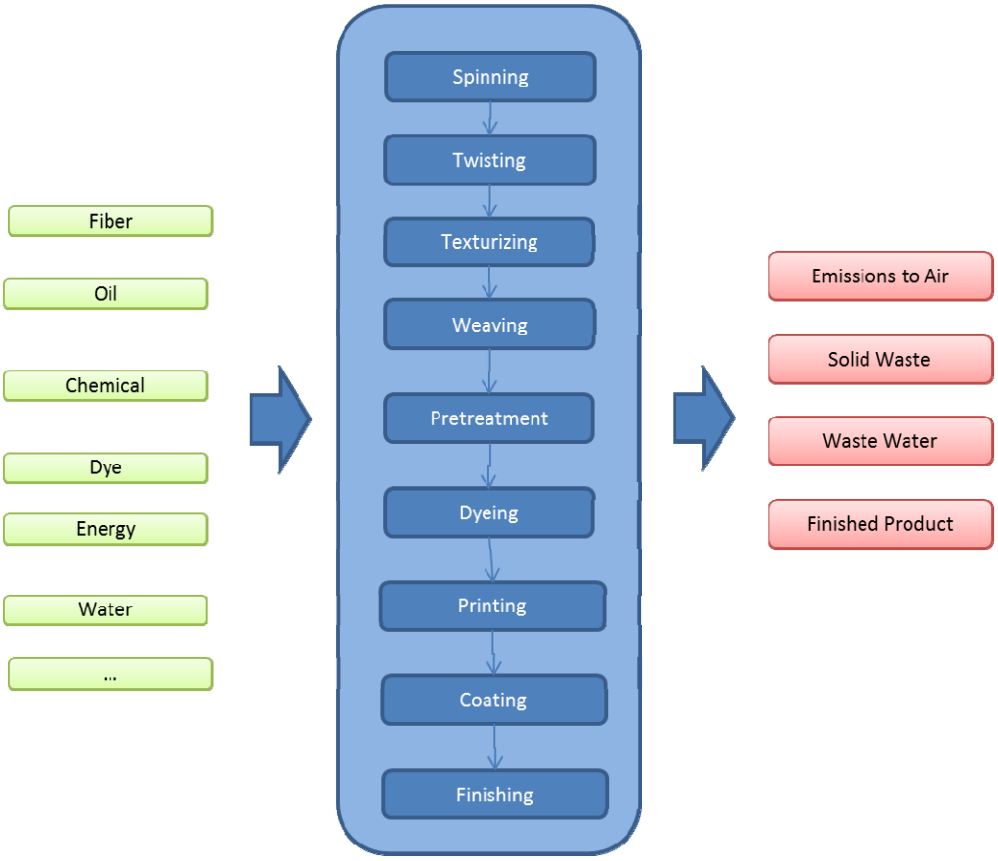


Figure: Process overview diagram for the production stage at a T-shirt company

List of processes within the system boundary: fibre production, spinning, twisting, texturising, weaving, pre-treatment, dyeing, printing, coating, finishing.

Collection of unit process - Resource Use and Emissions Profile data

Process name: finishing process

Process diagram: finishing refers to processes performed on yarn or fabric after weaving or knitting to improve the look and performance of the finished textile product

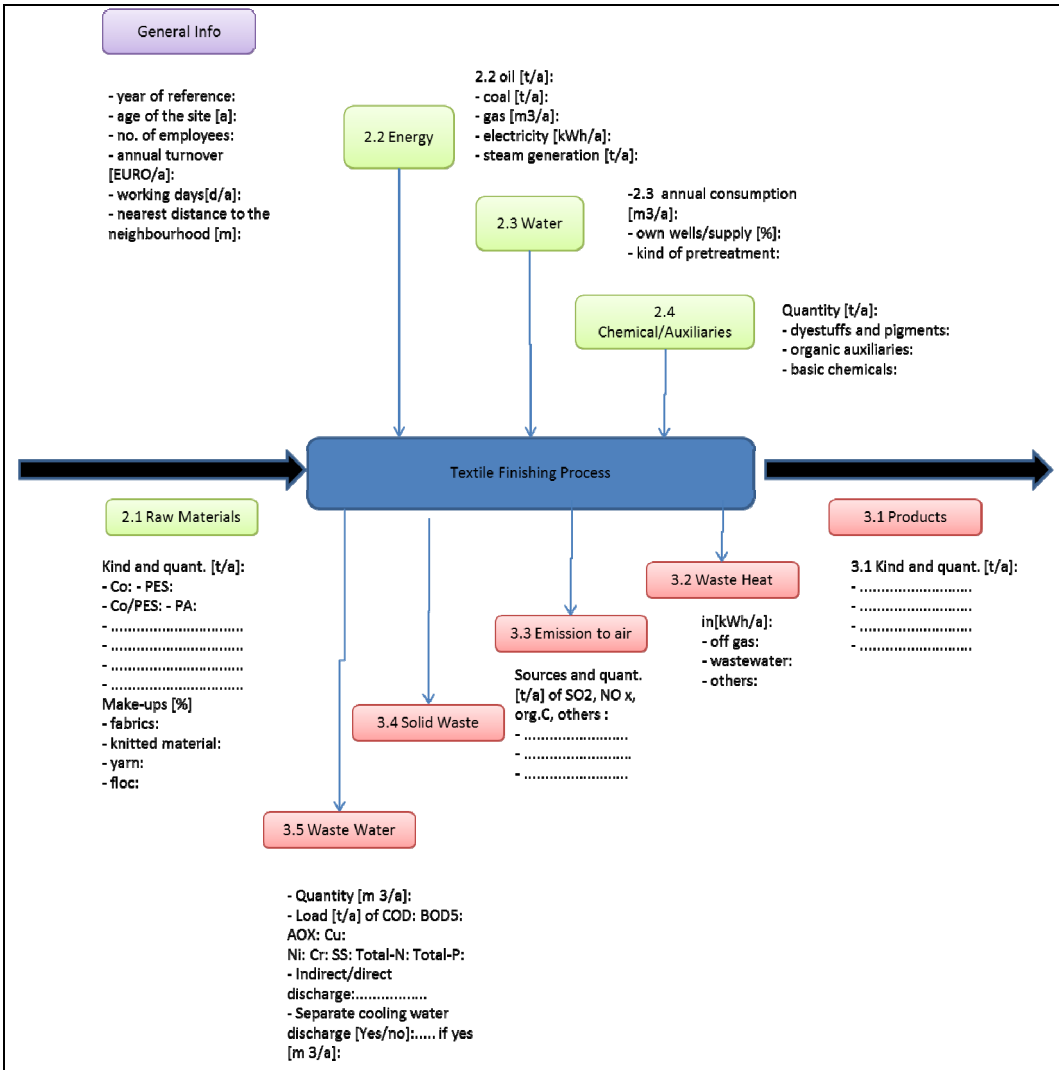


Figure: Process diagram – finishing process

Input

Code	Name	Amount	Unit

Output (Per reference flow)

Code	Name	Amount	Unit

Table 10: Example of Resource Use and Emissions Profile[107]

Parameter	Unit/kg	Amount
Energy consumption (non-elementary)	MJ	115.5
Electricity (elementary)	MJ	34.6
Fossil Fuel (elementary)	MJ	76
Others (non-elementary)	MJ	4.9
Non-renewable resources (non-elementary)	kg	2.7
Natural gas (elementary)	kg	0.59
Natural gas, feedstock (elementary)	kg	0.16
Crude oil (elementary)	kg	0.57
Crude oil, feedstock (elementary)	kg	0.48
Coal (elementary)	kg	0.66
Coal, feedstock (elementary)	kg	0.21
LPG (elementary)	kg	0.02
Hydro power (MJel) (elementary)	MJ	5.2
Water (elementary)	kg	12400
Emissions to air (elementary flows)		
CO_2	g	5,132
CH_4	g	8.2
SO_2	g	3.9
No_x	g	26.8
CH	g	25.8
CO	g	28
Emission to water (elementary flows)		
COD Mn	g	13.3
BOD	g	5.7
Tot-P	g	0.052
Tot-N	g	0.002

[107] A distinction is made between "**elementary flows**" (i.e. (ISO 14044, 3.12) "*material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation.*") and "**non-elementary flows**" (i.e. all the remaining inputs (e.g. electricity, materials, transport processes) and outputs (e.g. waste, by-products) in a system that need further modelling efforts to be transformed into elementary flows)

Annex IV: Identifying Appropriate Nomenclature and Properties for Specific Flows

The principal target audience for this Annex are experienced Environmental Footprint practitioners and reviewers.

This Annex is based on the "International Reference Life Cycle Data System (ILCD) Handbook - Nomenclature and other conventions" (European Communities, JRC–IES, 2010). If further information and background is required on nomenclature and naming conventions, please refer to the aforementioned document, which is available at: http://lct.jrc.ec.europa.eu/.

Different groups often use considerably different nomenclature and other conventions. As a consequence, Resource Use and Emissions Profiles (for Life Cycle Assessment practitioners: Life Cycle Inventory (LCI) datasets) are incompatible on different levels, thereby strongly limiting the combined use of Resource Use and Emissions Profiles datasets from different sources or an efficient, electronic exchange of data among practitioners. This situation also hampers a clear, unambiguous and efficient understanding and review of EF and LCA study reports.

The purpose of this Annex is to support data collection, documentation and use for Resource Use and Emissions Profiles and LCIs in EF and LCA studies by providing a common nomenclature and provisions on related topics. The document also forms the basis for a common reference elementary flow list for use in both EF and LCA activities.

This supports efficient EF, LCA and data exchange among different tools and databases.

The goal is to guide data collection, naming, and documentation in such a way that the data:

- Are meaningful, precise and useful for further EF impact assessments, interpretation and reporting;
- Can be compiled and provided in a cost-efficient way;
- Are comprehensive and do not overlap;
- Can be efficiently exchanged among practitioners who have different databases and software systems, thereby reducing the likelihood of errors.

This nomenclature and other conventions focus on elementary flows, flow properties and the related units, and give suggestions for the naming of process datasets, product and waste flows, for better compatibility among different database systems. Basic recommendations and requirements are also given on the classification of source and contact datasets.

Table 11 lists the ILCD Handbook rules that are required in PEF studies. Table 12 specifies the rule-category and the relevant chapters of the ILCD Handbook.

Table 11: Required rules for each flow type.

Items	Required Rules from the ILCD - Nomenclature (see Table 14)
Raw material, Input	2, 4, 5
Emission, output	2, 4, 9
Product flow	10, 11, 13, 14, 15, 16, 17

Table 12: Nomenclature Rules.

Rule #	Rule Category	Chapter section in ILCD Handbook - Nomenclature and other conventions
2	"Elementary flow categories" by issuing / receiving environmental compartment	Chapter section 2.1.1
4	Further differentiation of issuing/receiving environmental compartments	Chapter section 2.1.2
5	Additional, non-identifying classification of "Resources from ground" elementary flows	Chapter section 2.1.3.1
9	Recommended for both technical and non-technical target audience: additional, non-identifying classification of emissions	Chapter section 2.1.3.2
10	Top-level classification of Product flows, Waste flows, and Processes	Chapter section 2.2
11	Second-level classifications of Product flows, Waste flows, and Processes (for preceding top-level classification)	Chapter section 2.2
13	“Base name” field	Chapter section 3.2
14	“Treatment, standards, routes” name field	Chapter section 3.2
15	“Mix type and location type” name field	Chapter section 3.2
16	“Quantitative flow properties” name field	Chapter section 3.2
17	Naming convention of flows and processes	Chapter section 3.2

Example of Identifying Appropriate Nomenclature and Properties for Specific Flows

Raw material, Input: Crude oil (Rules 2, 4, 5)

(1) Specify "elementary flow category" by the issuing / receiving environmental compartment:

Example: Resources - Resources from ground

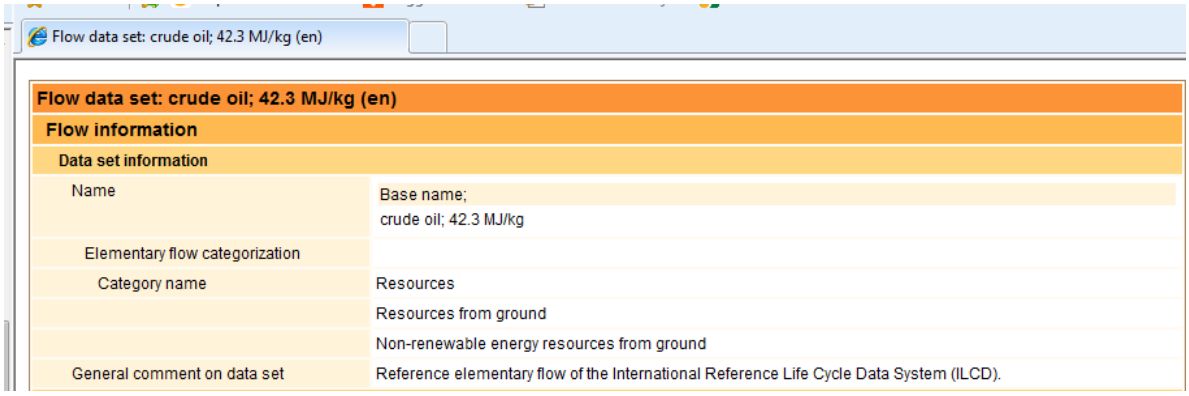
(2) Further differentiation of issuing / receiving environmental compartments

Example: Non-renewable energy resources from ground

(3) Additional, non-identifying classification for "Resources from ground" elementary flows

Example: Non-renewable energy resources from ground (e.g. "Crude oil; 42.3 MJ/kg net calorific value")

Flow dataset: Crude oil: 42.3 MJ/kg net calorific value



Ref: http://lct.jrc.ec.europa.eu/

Emission, output: Example: Carbon Dioxide (Rules 2, 4, 9)

(1) Specify "elementary flow categories" by issuing / receiving environmental compartment:

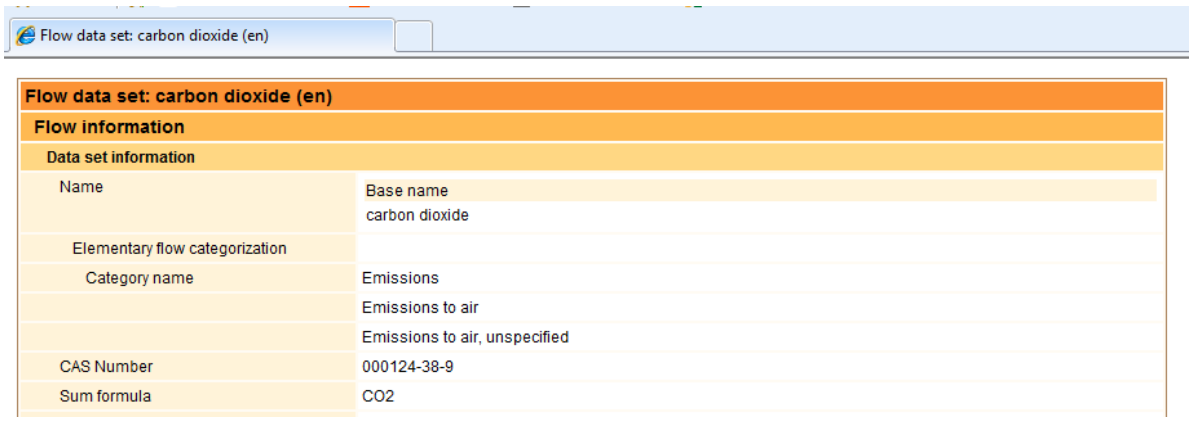
Example: Emissions – Emissions to air - Emissions to air, unspecified

(2) Further differentiation of issuing / receiving environmental compartments

Example: “Emission to air, DE”

(3) Additional, non-identifying classification of emissions

Example: Inorganic covalent compounds (e.g. "Carbon dioxide, fossil", "Carbon monoxide", "Sulphur dioxide", "Ammonia", etc.)



Ref: http://lct.jrc.ec.europa.eu/

Product flow: Example: T-shirt (Rules 10-17)

(1) Top-level classification for Product flows, Waste flows, and Processes:

Example: “System”

(2) second-level classifications for Product flows, Waste flows, and Processes (from preceding top-level classification):

Example: “Textiles, furniture and other interiors”

(3) “Base name” field:

Example: “Base Name: White polyester T-shirt”

(4) “Treatment, standards, routes” name field:

Example: “ ”

(5) “Mix type and location type” name field:

“Production mix, at point of sale”

(6) “Quantitative flow properties” name field:

Example: “160 grammes polyester”

(7) naming convention of flows and processes.

<“Base name”; “Treatment, standards, routes”; “Mix type and location type”; “Quantitative flow properties”>.

Example: “White polyester T-shirt; product mix at point of sale; 160 grammes polyester”

Annex V: Dealing with Multi-functionality in Recycling Situations

Dealing with multi-functionality of products is particularly challenging when reuse, recycling or energy recovery of one (or more) of these products is involved as the systems tend to get rather complex.

The overall resulting Resource Use and Emissions Profile (RUaEP) per unit of analysis can be estimated using the formula provided below, which:

- is applicable for both open-loop[108] and closed-loop[109] recycling;
- If relevant/applicable, and can accommodate re-use of the product being assessed. This is modelled in the same manner as recycling;
- if relevant/applicable, can accommodate downcycling, i.e. any differences in quality between the secondary material (i.e. recycled or reused material) and the primary material (i.e. virgin material);
- If relevant/applicable, can accommodate energy recovery.

The quantitative figures for the relevant parameters involved need to be gathered in order to use the formula provided below to estimate overall RUaEP per unit of analysis. Whenever feasible, these should be determined based on data associated with the actual processes involved. However, this may not always be possible / feasible and data may have to be found elsewhere (please notice that the explanation provided hereafter for each term of the formula contains a recommendation on how/where to find missing data).

The RUaEP per unit of analysis[110] is calculated with the following formula.

$$(1-R_1)\times E_V + R_1 \times E_{recycled} + R_2 \times \left(E_{recyclingEoL} - E^*_V \times \frac{Q_S}{Q_P} \right) + R_3 \times \left(E_{ER} - LHV \times X_{ER} \times E_{SE} \right) + (1-R_2-R_3)\times E_D$$

The abovementioned formula can be divided into 5 blocks:

$VIRG_{IN} + REC_{IN} + REC_{OUT} + ER_{OUT} + DISP_{OUT}$

These are interpreted as follows (the different parameters are explained in detail hereafter):

- $VIRG_{IN} = (1-R_1)\times E_V$ represents the RUaEP from virgin material acquisition and pre-processing.
- $REC_{IN} = R_1 \times E_{recycled}$ represents the RUaEP associated to the recycled material input and is proportional to the fraction of material input that has been recycled in a previous system.

[108] Open-loop recycling refers to those situations in which the material of the product system considered is partly or fully recycled into another product system.

[109] Closed-loop recycling refers to those situations in which the material of the product system considered is recycled back to the same product system.

[110] The unit of analysis can differ depending on the product/material assessed. In many cases this will be 1 kg of material, but may differ if relevant. For wood for example, it is more common to use 1 m^3 as unit of analysis (because the weight differs according to the water content).

- REC_{OUT} = $R_2 \times \left(E_{recyclingEoL} - E^*_V \times \frac{Q_S}{Q_P} \right)$ represents the RUaEP from the recycling (or re-use) process from which the credit from avoided virgin material input (accounting for any eventual downcycling) are subtracted.

- ER_{OUT} = $R_3 \times \left(E_{ER} - LHV \times X_{ER} \times E_{SE} \right)$ represents the RUaEP arising from the energy recovery process from which the avoided emissions arising from the substituted energy source have been subtracted.

- $DISP_{OUT}$ = $\left(1 - R_2 - R_3\right) \times E_D$ represents the net RUaEP from the disposal of the fraction of material that has not been recycled (or re-used) at End-of-Life or handed over to an energy recovery process.

Where:

- E_V = specific emissions and resources consumed (per unit of analysis) arising from the acquisition and pre-processing of virgin material. If this information is not available, generic data should be used which should be sourced according to the sources of generic data listed in section 5.8.

- E^*_V = specific emissions and resources consumed (per unit of analysis) arising from the acquisition and pre-processing of virgin material assumed to be substituted by recyclable materials:

    - If only closed-loop recycling takes place: $E^*_V = E_V$

    - If only open-loop recycling takes place: $E^*_V = E'_V$ represents to the input of virgin material that refers to the actual virgin material substituted through open-loop recycling. If this information is not available, assumptions should be made as to what virgin material is substituted, or average data should be used which should be sourced according to the sources of generic data listed in section 5.8. If no other relevant information is available it could be assumed that $E'_V = E_V$, as if closed-loop recycling had taken place.

- $E_{recycled}$ = specific emissions and resources consumed (per unit of analysis) arising from the recycling process of the recycled (or reused) material, including collection, sorting and transportation processes. If this information is not available, generic data should be used which should be sourced according to the sources of generic data listed in section 5.8.

- $E_{recyclingEoL}$ = specific emissions and resources consumed (per unit of analysis) arising from the recycling process at the end-of-life stage, including collection, sorting and transportation processes. If this information is not available, generic data should be used which should be sourced according to the sources of generic data listed in section5.8.

  Note: in closed loop recycling situations $E_{recycled} = E_{recyclingEoL}$ and $E^*_V = E_V$

- E_D = specific emissions and resources consumed (per unit of analysis) arising from disposal of waste material (e.g. landfilling, incineration, pyrolysis). If this information is not available, generic data

should be used which should be sourced according to the sources of generic data listed in section 5.8.

- E_{ER} = specific emissions and resources consumed (per unit of analysis) arising from the energy recovery process. If this information is not available, generic data should be used which should be sourced according to the sources of generic data listed in section 5.8.

- E_{SE} = specific emissions and resources consumed (per unit of analysis) that would have arisen from the specific substituted energy source. If this information is not available, generic data should be used which should be sourced according to the sources of generic data listed in section 5.8.

- R_1 [dimensionless] = "recycled (or reused) content of material", is the proportion of material in the input to the production that has been recycled in a previous system ($0=<R_1<=1$). If this information is not available, comprehensive and regularly updated statistical information on recycling rates and other relevant parameters can be obtained from suppliers such as Eurostat[111].

- R_2 [dimensionless] = "recycling (or reuse) fraction of material", is the proportion of the material in the product that will be recycled (or reused) in a subsequent system, i.e. the rate between recycled output and virgin material input. R_2 shall therefore take into account the inefficiencies in the collection and recycling (or reuse) processes ($0=<R_2=<1$). If this information is not available, comprehensive and regularly updated statistical information on recycling rates and other relevant parameters can be obtained from suppliers such as Eurostat[112].

- R_3 [dimensionless] = the proportion of material in the product that is used for energy recovery (e.g. incineration with energy recovery) at EoL ($0=<R_3=<1$). If this information is not available, comprehensive and regularly updated statistical information on recycling rates and other relevant parameters can be obtained from suppliers such as Eurostat.

- LHV = Lower Heating Value [e.g. J/kg] of the material in the product that is used for energy recovery. This should be determined with an appropriate laboratory method. If this is not possible or feasible, generic data should be used (see, for example, the "ELCD Reference elementary flows"[113], and the ELCD database under EoL treatment / Energy recycling[114])

[111] Data on hazardous / non-hazardous waste generation and treatment per each Member State can be found at: http://epp.eurostat.ec.europa.eu/portal/page/portal/environment/data/main_tables;
Data on municipal solid waste generation and treatment per each Member Sate can be found at: http://europa.eu/rapid/pressReleasesAction.do?reference=STAT/12/48&format=HTML&aged=0&language=EN&guiLanguage=en; and at: http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tsdpc240&language=en;

[112] Data on hazardous / non-hazardous waste generation and treatment for each Member State can be found at: http://epp.eurostat.ec.europa.eu/portal/page/portal/environment/data/main_tables;
Data on municipal solid waste generation and treatment for each Member Sate can be found at: http://europa.eu/rapid/pressReleasesAction.do?reference=STAT/12/48&format=HTML&aged=0&language=EN&guiLanguage=en; and at: http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tsdpc240&language=en;

[113] http://lct.jrc.ec.europa.eu/assessment/publications

[114] http://lca.jrc.ec.europa.eu/lcainfohub/datasetList.vm?topCategory=End-of-life+treatment&subCategory=Energy+recycling

- X_{ER} [dimensionless] = the efficiency of the energy recovery process ($0<X_{ER}<1$), i.e. the ratio between the energy content of output (e.g. output of electricity) and the energy content of the material in the product that is used for energy recovery. X_{ER} shall therefore take into account the inefficiencies of the energy recovery process ($0=<X_{ER}<1$). If this information is not available, generic data should be used (see, for example, EoL treatment / Energy recycling in the ELCD database).

- Qs = quality of the secondary material, i.e. the quality of the recycled or reused material (see note below).

- Qp = quality of the primary material, i.e. the quality of the virgin material (see note below).

Note: Q_s/Q_p is a dimensionless ratio taken as an approximation for any differences in quality between the secondary material and the primary material ("downcycling"). Following the EF multi-functionality hierarchy (see section 5.10), the possibility of identifying a relevant, underlying physical relationship as a basis for the quality correction ratio will be assessed (the limiting factor shall be determining). If this is not possible, some other relationship shall be used, for example, economic value. In this case, the prices of primary versus secondary materials are assumed to serve as a proxy for quality. In such a situation, Qs/Qp would correspond to the ratio between the market price of the secondary material (Qs) and the market price of the primary material (Qp). Market prices of primary and secondary materials can be found in online sources[115]. The quality aspects to be considered for the primary and secondary material shall be specified in the PEFCR.

[115] For instance: http://data.worldbank.org/data-catalog/commodity-price-data; http://www.metalprices.com/; http://www.globalwood.org/market/market.htm; http://www.steelonthenet.com/price_info.html; http://www.scrapindex.com/index.html.

Annex VI: Guidance on the calculation of Direct Land Use Change emissions relevant for climate change

Credits associated with temporary (carbon) storage or delayed emissions shall not be considered in the calculation of the PEF for the default impact categories, unless otherwise specified in a supporting PEFCR. However, credits associated with temporary (carbon) storage or delayed emissions may be reported under "additional environmental information" if foreseen and justified in the goal/scope of the PEF study.

INTRODUCTION

This Annex gives guidance on the calculation of carbon stock emissions related to land use change contributing to climate change. It is divided into two sections. The first section presents guidance on the inclusion of land use change emissions in the calculation of climate change. The second section provides a summary of the equations used in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) for the calculation of greenhouse gas emissions from agriculture, forestry and other land use.

For the cases in which the life cycle of the organisation includes products consisting of biogenic materials, the impact of land use change on climate change must be accounted for.

The impact of land use change on climate change results basically from a change in carbon stocks in land. The carbon stock changes in ecosystems can be divided into three main carbon storage/sink pools, some including sub-pools: (i) biomass (above- and belowground); (ii) dead organic matter (dead wood and litter) and (iii) soil organic carbon (IPCC 2006).

The impact on climate is a result of biogenic CO_2 emissions and removals caused by carbon stock changes, and biogenic and non-biogenic CO_2, N_2O and CH_4 emissions (e.g. biomass burning). Biogenic emissions include those resulting from the burning (combustion) or degradation of biogenic materials, wastewater treatment and biological sources in soil and water (including CO_2, CH_4 and N_2O), while biogenic removals correspond to the uptake of CO_2 during photosynthesis. Non-biogenic emissions correspond to all emissions resulting from non-biogenic sources, such as fossil-based materials, while non-biogenic removals correspond to the CO_2 that is removed from atmosphere by a non-biogenic source (WRI and WBCSD 2011b).

Changes in land use might be classified as being direct or indirect:

Direct Land Use Changes (dLUC) occur as the result of a transformation from one land use type into another, which takes place in a unique land cover, possibly incurring changes in the carbon stock of that specific land, but not leading to a change in another system.

Indirect Land Use Changes (iLUC) occur when a certain change in land use induces changes outside the system boundaries, i.e. in other land use types. These indirect effects can be assessed by economic modelling of the demand for land or by modelling the relocation of activities on a global scale. The main drawbacks of such models are their reliance on trends, which might not reflect future developments, and their commonly basis on political decisions.

Figure 6 shows the schematic representation of both direct and indirect land use changes, for which biofuel production is taken as the introduced land use change.

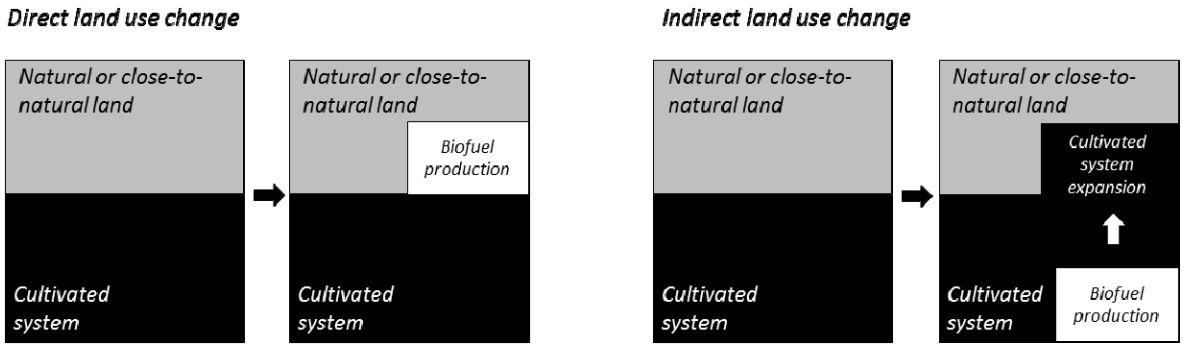


Figure 6: Schematic representation of direct and indirect land use changes (CE Delft 2010).

No widely accepted provisions exist for the calculation of emissions resulting from indirect land use change, so no specific recommendations or guidance are supplied here. These shall not be assessed in the PEF study.

For the release and uptake of CO_2 caused by direct land use change, the use of the most recent IPCC CO_2 emission factors shall be used, unless more accurate, specific data are available. Detailed provisions are given in this document, based on the main IPCC equations (IPCC 2006) to calculate emissions resulting from land use change. Other emissions as a result of land use change (e.g. NO_3 losses to water, emissions from biomass burning, soil erosion, etc.) should be measured or modelled for the particular case or using authoritative sources.

Some of the current mostly applied methodologies for accounting for greenhouse gas (GHG) emissions and removals from land use changes have been analysed, including (i) AFNOR BP X 30-323; (ii) ISO 14067; (iii) BSI PAS 2050:2011 and PAS 2050-1:2012 (iv) WRI/WBCSD GHG Protocol Product Standard; and the (v) EC ILCD Handbook.

In coherence with the European Food Sustainable Consumption and Production Roundtable (Food SCP) and the published ENVIFOOD Protocol, the application of PAS 2050:2011 (BSI 2011) is recommended, supplemented by the PAS2050-1 (BSI 2012), for the assessment GHG emissions from the cradle-to-gate (from raw material extraction to manufacturing) stages of the life cycle of horticultural products. The PAS 2050-1:2012 takes into account the emissions and removals involved in the cultivation of a horticultural crop product and should supplement rather than substitute PAS 2050:2011. A supplementary excel file is also provided by the British Standard Institution (BSI) for the PAS 2050-1:2012 calculations. It is important to emphasise that both standards address only the impacts contributing to global warming potential. Complementary information is supplied by the GHG Protocol (WRI and WBCSD 2011b).

In this Guide, the general provisions of the recommended PAS 2050:2011 are highlighted, together with the equations used in the 2006 IPCC GHG emissions and removals calculations.

PART 1: GUIDANCE ON THE INCLUSION OF LAND USE CHANGE EMISSIONS AND REMOVALS ON THE CALCULATION OF IMPACT ON CLIMATE CHANGE

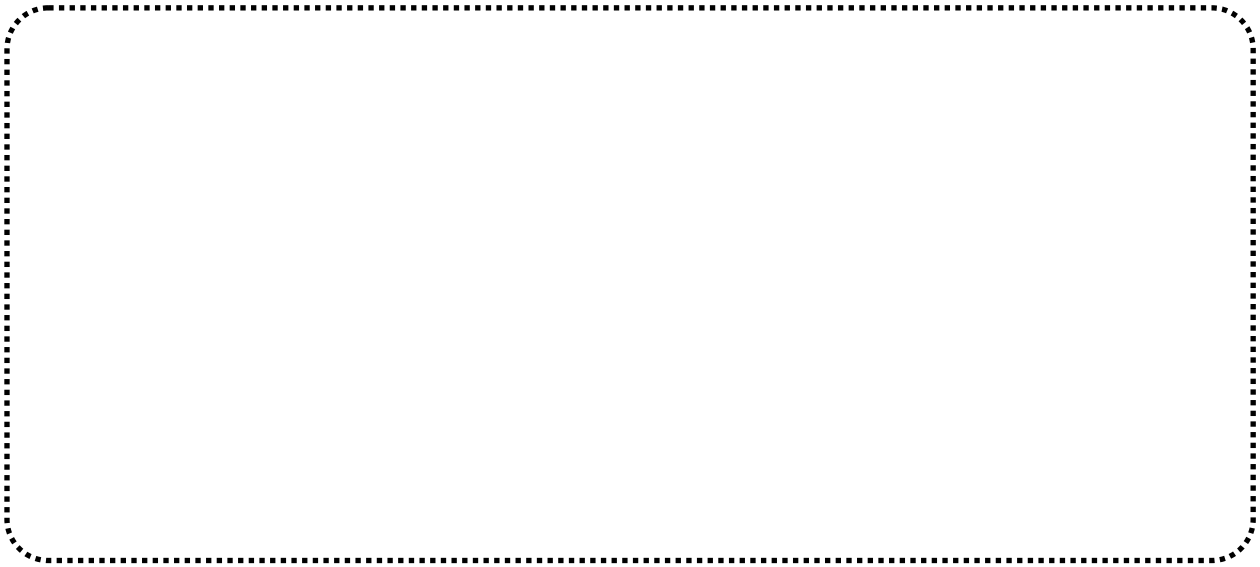
According to the GHG Protocol (WRI and WBCSD 2011b), land use change impacts on climate change result from:

- "*If companies are not sure whether emissions are from a biogenic or non-biogenic source, they should include those emissions as non-biogenic*"

This Annex provides guidance for specific situations, following the recommendations of PAS 2050:2011 (BSI 2011), PAS 2050-1;2012 (BSI 2012) and the GHG Protocol (WRI and WBCSD 2011b).

Knowledge on previous LU category and production location

Following PAS 2050:2011 (BSI 2011), three distinct situations (and respective guidelines) can be identified, depending on the availability of information about the location of production and the previous land use category:



I. EMISSIONS AND REMOVALS FROM LAND USE CHANGE (LUC)

General emissions and removals to be included in the assessment

Following PAS 2050:2011 (BSI 2011) the emissions and removals to be included in the assessment are:

- **Gases included** in **Annex A of the PAS 2050:2011**

CO_2 removals by carbon storage in products

Following PAS 2050:2011 (BSI 2011) CO_2 removals by carbon storage in products:

"shall be included whenever a part or all removed carbon is not emitted

Soil carbon change (more than that included in the IPCC factors)

Following PAS 2050:2011 (BSI 2011) CO_2 removals by carbon storage in products:

Aircraft emissions and removals

Following PAS 2050:2011 (BSI 2011):

"**No multiplier or other correction shall be applied** to the GWP of emissions and removals arising from aircraft transport" (BSI 2011).

Treatment of land use change

Following PAS 2050:2011 (BSI 2011):

> "GHG emissions and removals arising from **direct land use change** shall be assessed for **any input** to the life cycle of a product originating **from that land**" (BSI 2011).
>
> "Emissions arising from **indirect land use change** is **not included**" (BSI 2011) in the PAS 2050.

Offsetting

Following PAS 2050:2011 (BSI 2011):

> "GHG emissions offset mechanisms, including but not limited to voluntary offset schemes or nationally or internationally recognized offset mechanisms, shall not be used at any point in the assessment of the GHG emissions of the product" (BSI 2011).

II. ASSESSMENT PERIOD FOR THE INCLUSION OF GHG EMISSIONS AND REMOVALS: TIME PERIOD OF THE INVENTORY

This guidance follows the specification of the **100-year period for the assessment period following the formation of the product** (IPCC 2006). As specified in the GHG Protocol (WRI and WBCSD 2011b), the end-of-life stage should be included, even if the use stage is longer than the 100 years.

III. ASSESSMENT PERIOD FOR LAND USE CHANGE IMPACTS

Following the recommendations from both the GHG Protocol (WRI and WBCSD 2011b) and PAS 2050:2011 (BSI 2011), carbon stock change occurring (i) within a **20-year** period (default period according to IPCC (IPCC 2006), or (ii) a **single harvest period from the extraction of the evaluated product** (even if longer than 20 years) should be included in the calculation. These changes must be a result of human interventions and the longest period should be chosen.

Following PAS 2050:2011 (BSI 2011), if the information on the period cannot be included, one of the two following options shall be chosen regarding the date on which the land use change occurred:

IV. LIMITED DATE FOR VALIDITY OF ANALYSIS

According to the PAS 2050:2011 (BSI 2011), the validity of the analysis is limited to a "maximum period of two years, unless there is a change in the LC of the product whose GHG emissions are being assessed, in which situation the validity ceases".

V. UNCERTAINTY

In accordance with PAS 2050:2011 (BSI 2011), uncertainties can be reduced in the following ways:

PART 2: GUIDANCE ON THE CALCULATIONS ACCORDING TO IPCC 2006 GUIDELINES FOR NATIONAL GREENHOUSE GAS INVENTORIES

According to the IPCC (2003), three distinct tiers are defined for estimating GHG emissions and removals:

- **Tier 1 -** "methodologies based on activity data that are spatially coarse, such as nationally or globally available estimates of deforestation rates, agricultural production statistics, and global land cover maps" (IPCC 2003).
- **Tier 2 -** "methodologies applying emission factors and activity data which are defined by the country for the most important land uses/activities" (IPCC 2003).
- **Tier 3 -** "methodologies using models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by high-resolution activity data and disaggregated at sub-national to fine grid scales" (IPCC 2003). The methods applied in Tier 3 provide a higher certainty of results.

The calculations are mainly carried out according to six land use categories IPCC (2006):

- Forest land;
- Cropland;
- Grassland;
- Wetlands;
- Settlements;
- Other land.

Further, according to the IPCC (2006), three main carbon pools are used in the calculation of carbon-stock changes for each land-use category:

- Biomass (above- and belowground);
- Dead Organic Matter (dead wood and litter);
- Soils (soil organic matter).

Summary of equations for the calculation of greenhouse gas emissions and removals resulting from carbon-stock changes in biomass (above- and belowground), dead organic matter and soils (IPCC 2006)

The equations refer to the methods of Tiers 1, 2 and 3 and to land remaining in the same land-use category and/or land converted into another land-use category for three carbon pools: biomass (Table 14), dead organic matter (Table 14) and soils (Table 15).

BIOMASS CHANGE (GAIN or LOSS)

Table 13: 2006 IPCC Guideline Methods for estimating change in carbon stocks in biomass (IPCC 2006)

	LAND REMAINING IN THE SAME LAND USE CATEGORY	LAND CONVERTED TO ANOTHER LAND USE CATEGORY
Methods for estimating total change in C stocks in biomass (ΔC_B)	**Tier 1** **Eq. 2.7** (p.2.12): Annual change in C stocks in biomass in land remaining in a particular land-use category (**Gain-Loss Method**) **Tiers 2 & 3** **Eq. 2.8** (p.2.12): Annual change in C stocks in biomass in land remaining in the same land-use category (**Stock-Difference Method**) **OBS**: *Default CF value of aboveground forest biomass: 0.47 (see Table 4.3, p. 4.48). Other values are given in Tables 4.7 (p. 4.53, forests) and 4.8 (p. 4.54, forest*	**Tier 1** **Eq. 2.7** (p.2.12): Annual change in C stocks in biomass in land remaining in a particular land-use category (**Gain-Loss Method**) **Tiers 2 & 3** **Eq. 2.15** (p.2.20): Annual change in biomass C stocks on land converted to another land-use category **Eq. 2.16** (p.2.20): Initial change in biomass carbon stocks on land converted to another land category

	plantations)	
Methods for estimating increase in C stocks in biomass (ΔC_G) **-** **Biomass (Gain):** *Total aboveground and belowground biomass growth*	**Tiers 1, 2 & 3** **Eq. 2.9** (p.2.15): Annual increase in biomass C stocks due to biomass increment in land remaining in the same land-use category In which $G_{TOTAL\ i,j}$ is calculated using **Eq. 2.10**: **Eq. 2.10** (p.2.15) Average annual increment in biomass: **a) Tier 1:** biomass increment data (dry matter) are used directly; **b) Tiers 2 & 3:** net annual increment data are used to estimate G_W by applying a biomass conversion and expansion factor.	**Tiers 1, 2 & 3** **Eq. 2.9** (p.2.15): Annual increase in biomass C stocks due to biomass increment in land remaining in the same land-use category In which $G_{TOTAL\ i,j}$ is calculated using **Eq. 2.10**: **Eq. 2.10** (p.2.15) Average annual increment in biomass: **a) Tier 1:** biomass increment data (dry matter) are used directly; **b) Tiers 2 & 3:** net annual increment data are used to estimate G_W by applying a biomass conversion and expansion factor.
Methods for estimating decrease in C stocks in biomass (ΔC_L) **-** **Biomass (Loss)** *Roundwood removal/harvest, Fuelwood*	**Tier 1 (Gain-Loss Method)** **Eq. 2.11** (p.2.16) Annual decrease in C stocks due to biomass losses in land remaining in the same land-use category **Eq. 2.12** (p.2.17) Annual C loss in biomass due to wood removals	**Tier 1 (Gain-Loss Method)** **Eq. 2.11** (p.2.16) Annual decrease in C stocks due to biomass losses in land remaining in the same land-use category **Eq. 2.12** (p.2.17) Annual C loss in biomass due to wood removals

removal/ harvest, Gains & losses from disturbances (e.g. fire, insects, diseases)	**Eq. 2.13** (p.2.17) Annual C loss in biomass due to fuelwood removal For **Tier 1**, "R must be set to zero if no changes of belowground biomass are assumed". **Eq. 2.14** (p.2.18) Annual C loss in biomass due to disturbances **OBS:** "*The **Tier 1** assumption is that all of $L_{disturbances}$ is emitted in the year of disturbance. **Tier 2 and 3** methods assume that some of this carbon is emitted immediately and some is added to the dead organic matter pools (dead wood, litter) or HWP*".	**Eq. 2.13** (p.2.17) Annual C loss in biomass due to fuelwood removal For **Tier 1**, "R must be set to zero if no changes of belowground biomass are assumed". **Eq. 2.14** (p.2.18) Annual C loss in biomass due to disturbances **OBS:** "*The **Tier 1** assumption is that all of $L_{disturbances}$ is emitted in the year of disturbance. **Tier 2 and 3** methods assume that some of this carbon is emitted immediately and some is added to the dead organic matter pools (dead wood, litter) or HWP*". **OBS:** *"Tier 1 employs a default assumption that there is no change in initial biomass carbon stocks due to conversion", so the same calculation used for "land remaining in the same land use category can be applied*". **Tiers 2 & 3** **Eq. 2.15** (p.2.20) Annual change in biomass C stocks on land converted to another land use category **Eq. 2.16** (p.2.20) Initial change in biomass C stocks on land converted to another land use category

CHANGE IN CARBON STOCKS IN DEAD ORGANIC MATTER (DOM)

Table 14: 2006 IPCC Guideline Methods for estimating change in carbon stocks in dead organic matter (IPCC 2006)

	LAND REMAINING IN THE SAME LAND USE CATEGORY	LAND CONVERTED TO ANOTHER LAND USE CATEGORY
Methods for estimating annual changes in carbon stock in Dead Organic Matter (DOM) pools	**Tier 1** *"The **Tier 1** assumption for both dead wood and litter pools for all land-use categories is that their **stocks are not changing over time** if the land remains within the same land use category. Thus the carbon in biomass killed during a disturbance or management event (less removal of harvested wood products) is assumed to be released entirely to the atmosphere in the year of the event*". **For Tiers 2 & 3** **Eq. 2.17** (p.2.21) Annual change in C stocks in dead organic matter **Eq. 2.18** (p.2.23) Annual change in C stocks in Dead Wood (DW) or Litter (LT) (**Gain-Loss Method**) **Eq. 2.19** (p.2.23) Annual change in C stocks in DW or LT (**Stock-Difference Method**) **OBS**: *"whenever the stock change method is used, the area used in the carbon stock calculations at times t_1 and t_2 must be identical". (…) "It's good practice to use the area at the end of the inventory period (t_2) to define the area of land remaining in the land-use category*."	**Tier 1** "***Tier 1** method assume that all carbon contained in biomass killed during a land-use conversion event (less harvested products that are removed) is **emitted directly to the atmosphere and none is added to dead wood and litter pools"**. **For Tiers 2 & 3** **Eq. 2.23** Annual change in C stocks in DW and LT due to land conversion *"The Tier 1 assumption is that DOM pools is non-forest land categories after the conversion are zero, i.e. they contain no carbon. The Tier 1 assumption for land converted from forest to another land-use category is that all DOM carbon losses occur in the year of land-use conversion. Conversely, conversion to Forest Land results in buildup of litter and dead wood carbon pools starting from zero carbon in those pools. DOM carbon gains on land converted to forest occur linearly, starting from zero, over a transition period (default assumption is 0 years). This default period may be appropriate for litter carbon stocks, but in temperate and boreal regions it is probably too short for dead wood carbon stocks".*

	Input of biomass to dead organic matter **Eq. 2.20** (p.2.24) Annual carbon in biomass transferred to dead organic matter **Eq. 2.21** (p.2.24) Annual biomass carbon loss due to mortality **Eq. 2.22** (p.2.25) Annual carbon transfer due to slash & burn	

CHANGE IN CARBON STOCKS IN SOILS

Table 15: 2006 IPCC Guideline Methods for estimating change in carbon stocks in soils (IPCC 2006)

	LAND REMAINING IN THE SAME LAND USE CATEGORY	LAND CONVERTED TO ANOTHER LAND USE CATEGORY
Methods for estimating soil carbon change	**Soil C estimation methods** **Eq. 2.24** (p.2.29) Annual change in carbon stocks in soils **OBS**: "*No Tier 1 or 2 methods are provided for estimating the change in soil inorganic C stocks due to limited scientific data for derivation of stock change factors; thus the net flux for inorganic C stocks is assumed to be zero*". **Tiers 1 & 2** **Mineral soils** **Eq. 2.25** Annual change in organic carbon stocks in mineral soils Use of **Table 2.3** (p.2.31) Default reference (under native vegetation) soil organic C stocks (SOC_{REF}) for mineral soils Use of **Table 5.5** (p.5.17 and 5.18) Relative stock change factors for different management activities on **cropland** (over 20 years) Use of **Table 6.2** (p.6.16) Relative stock change factors for **grassland** management (time dependence (D) 20 years)	**Soil C estimation methods** **Eq. 2.24** (p.2.29) Annual change in carbon stocks in soils **OBS**: "*No Tier 1 or 2 methods are provided for estimating the change in soil inorganic C stocks due to limited scientific data for derivation of stock change factors; thus the net flux for inorganic C stocks is assumed to be zero*". **Tiers 1 & 2** **Mineral soils** **Eq. 2.25** Annual change in organic carbon stocks in mineral soils Use of **Table 2.3** (p.2.31) Default reference (under native vegetation) soil organic C stocks (SOC_{REF}) for mineral soils Use of **Table 5.5** (p.5.17 and 5.18) Relative stock change factors for different management activities on **cropland** (over 20 yrs) Use of **Table 6.2** (p.6.16) Relative stock change factors for **grassland** management (time dependence, D, 20 yrs)

	Organic soils **Eq. 2.26** (p.) Annual carbon loss from drained organic soils (CO_2) **OBS**: "*Essentially, Tiers 1 and 2 represent land-use and management impacts on soil C stocks as a linear shift from one equilibrium state to another*".	**Organic soils** **Eq. 2.26** Annual carbon loss from drained organic soils (CO_2) **OBS:** "*Essentially, Tiers 1 and 2 represent land-use and management impacts on soil C stocks as a linear shift from one equilibrium state to another*".

(INFORMATIVE)

Annex VII: Example for a PEFCRs for intermediate paper products - Data quality requirements

The following table provides an example of data quality requirements and related data-quality level taken from existing PEFCRs for intermediate paper products.

Table 16: Example of data quality requirements for intermediate papers products[116]

			Data quality elements					
			Representativeness					
Quality level	Quality rating	Definition	Technological	Geographical	Time-related:	Completeness	Methodological AppropriatenessComp liency and Consistency	Precision /uncertainty
Excel lent	1	Meets the criterion to a very high degree, without need for improvement.	E.g. Process is same. For electricity from grid, average technology as country- specific consumption mix.	Country specific data o	≤ 3 year old data	Very good compl etenes s (≥ 90 %)	Full compliance with all requirements of the PEF guide	Very low uncertai nty (≤ 7 %)
Very good	2	Meets the criterion to a high degree, with little significant need for improvement.	E.g. average technology as country- specific consumption mix.	Central Europe, North Europe, r represen tative EU 27 mix,	3-5 years old data	Good compl etenes s (80 % to 90 %)	Attributional Process based approach AND following three method requirements of the PEF guide met: (1) Dealing with multi-functionality; (2) End of life modelling; (3) System boundary.	Low uncertai nty (7 % to 10 %)
Good	3	Meets the criterion to an acceptable degree, but merits improvement.	E.g. average technology as country- specific production mix or average technology as average EU consumption mix.	EU-27 countrie s, other Europea n country	5-10 years old data	Fair compl etenes s (70 % to 80 %)	Attribution Process based approach AND two of the following three method requirements of the PEF guide met: (1) Dealing with multi-functionality; (2) End of life modelling; (3) System boundary.	Fair uncertai nty (10 % to 15 %)
Fair	4	Does not meet the criterion to a sufficient degree, but rather requires improvement.	E.g. average technology as country- specific consumption mix of a group of similar products	Middle east, North-America, Japan etc.	10-15 years old data	Poor compl etenes s (50 % to 70 %)	Attributional Process based approach AND one of the following three method requirements of the PEF guide met: (1) Dealing with multi-functionality; (2) End of life modelling; (3) System boundary.	High uncertai nty (15 % to 25 %)
Poor	5	Does not meet the criterion. Substantial improvement is necessary.	E.g. other process or unknown na	Global data or unknow n	≥ 15 years old data	Very poor or unkno wn compl etenes s (< 50 %)	Attributional Process based approach BUT:None of the following three method requirements of the PEF guide met: (1) Dealing with multi-functionality; (2) End of life modelling; (3) System boundary.	Very high uncertai nty (>25 %)

[116] This table is taken from the draft document "Product Footprint Category Rules (PFCR) for Intermediate Paper Products" (2011) by the Confederation of European Paper Industries (CEPI), which was based on a draft version of this PEF Guide

Annex VIII: Mapping of terminology used in this PEF Guide with ISO terminology

This annex provides a mapping of the key terms used in this PEF Guide with the corresponding terms used under ISO 14044:2006. The reason for diverging from the ISO terminology is to make the PEF Guide more accessible to its target audience, which also includes groups that do not necessarily have strong background knowledge of environmental assessment. The tables below provide such a mapping of diverging terms.

Table 17: Mapping of key terms

Terms used in ISO 14044:2006	Correspondent terms used in this PEF guide
Functional unit	Unit of analysis
Life cycle inventory analysis	Resource Use and Emissions Profile
Life cycle impact assessment	Environmental footprint impact assessment
Life cycle interpretation	Environmental footprint interpretation
Impact category	Environmental footprint impact category
Impact category indicator	Environmental footprint impact category indicator

Table 18: Mapping of data quality criteria

Terms used in ISO 14044:2006	Correspondent terms used in this PEF guide
Time-related coverage	Time-related representativeness
Geographical coverage	Geographical representativeness
Technology coverage	Technological representativeness
Precision	Parameter uncertainty
Completeness	Completeness
Consistency	Methodological Appropriateness and Consistency
Sources of the data	Covered under “Resource Use and Emissions Profile”
Uncertainty of the information	Covered under “Parameter uncertainty”

Annex IX: PEF Guide and ILCD Handbook: major deviations

Where there are discrepancies between the PEF Guide and the ILCD Handbook, the PEF Guide takes precedence.

This annex points out the most important aspects of how this PEF Guide deviates from the ILCD Handbook, and provides a concise justification for these deviations. It should be noted, however, that the ILCD Handbook provides a starting point for the PEF developments. The ILCD Handbook may be further revised to bring it into line with the PEF Guide, and redundant sections that are addressed in the PEF Guide may be removed from the ILCD Handbook.

1. Target audience(s)
   As opposed to the ILCD Handbook, the PEF Guide is aimed at people who have limited knowledge of life cycle assessment. It is therefore written in a more accessible manner.
2. Completeness check
   The ILCD Handbook gives two options for checking completeness (1) completeness check at the level of each environmental impact and (2) completeness check at the level of the overall (i.e. aggregated) environmental impact. The PEF Guide considers completeness only at the level of each environmental impact. In fact, as the PEF Guide does not recommend any specific set of weighting factors, the overall (i.e. aggregated) environmental impact cannot be estimated.
3. Extension of the goal definition
   The PEF Guide is meant for use in specific applications, therefore extensions of the goal definition are not foreseen.
4. Scope definition includes “limitations”
   The scope definition of PEF Guide shall also include specifications of the limitations of the study. In fact, based on experience gained with the ILCD Handbook, the limitation can be properly defined only when practitioners have information regarding all aspects related to the goal definition and the function of the analysis.
5. Review procedure is defined in the goal definition
   The review procedure is essential to improve the quality of a PEF study, therefore it needs to be defined in the first step of the process, i.e. in the goal definition.
6. Screening step in place of the iterative approach
   The PEF Guide recommends that a screening step be conducted to obtain an approximate estimation of each environmental impact for the default EF impact categories. This step is similar to the iterative approach recommended in the ILCD Handbook.
7. Data quality rating
   The PEF Guide makes use of five rating levels for evaluating data quality (excellent, very good, good, fair, poor), compared to the three levels used in the ILCD Handbook. This will allow for the use of data with lower data quality levels in the study compared with those required by the ILCD Handbook. Also, the PEF Guide uses a semi-quantitative formula for assessing data quality, making it easier to achieve e.g. “good” data quality.
8. Multi-functionality decision hierarchy
   The PEF Guide provides a decision hierarchy for solving the multi-functionality of products which deviates from the approach endorsed by the ILCD Handbook. The PEF Guide also provides an

equation for solving multi-functionality in recycling and energy recovery situations at the end-of-life stage.

9. Sensitivity analysis
   Carrying out sensitivity analysis of the results is an optional step in the PEF Guide. This is expected to reduce the workload for users of the PEF Guide.

Annex X: Comparison of the key requirements of the PEF Guide with other methods

Although similar widely accepted product environmental accounting methods and guidance documents closely align on much of the methodological guidance they provide, there are some discrepancies and/or lack of clarity on a number of important decision points, which reduces the consistency and comparability of analytical outcomes. This annex provides a summary of selected key requirements of this PEF Guide and compares these with a number of existing methods. It is based on the document "Analysis of Existing Environmental Footprint Methodologies for Products and Organizations: Recommendations, Rationale, and Alignment", that can be accessed via http://ec.europa.eu/environment/eussd/corporate_footprint.htm. (EC-JRC-IES, 2011b). Different background fillings have been used to signal where the PEF Guide aligns with (light grey background), conflicts (diagonal stripes), or goes beyond another method (e.g. provides more detail or sets higher requirements) (dark grey background). Where no meaningful comparison is possible, no background filling is used.

Table 19: Comparison of key requirements: PEF Guide vs. other methods

Criteria	PEF Guide	ISO 14044 (2006) LCA – requirements and guidelines	ISO/DIS 14067 (2012): carbon footprint of product	ILCD Handbook – 1st Edition (2010)[117]	Ecological Footprint (2009)[118]	GHG Protocol (2011) (WRI – WBCSD)[119]	French Environmental Footprint (BPX 30-323)[120]	UK Product Carbon Footprint PAS 2050 (2011)[121]
LCT-based	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Applications	**In-house applications** may include support to	Identify opportunities to	Provide information to	Application situation "A":	Provide information to	Performance tracking include identifying	Provide information to	The method is intended to be used

[117] Available online at http://lct.jrc.ec.europa.eu/assessment/publications
[118] "Ecological Footprint Standards 2009" – Global Footprint Network. Available online at http://www.footprintnetwork.org/images/uploads/Ecological_Footprint_Standards_2009.pdf
[119] WRI and WBCSD (2011). Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Standard, 2011
[120] http://www2.ademe.fr/servlet/getDoc?id=11433&m=3&cid=96
[121] Available online at http://www.bsigroup.com/en/Standards-and-Publications/How-we-can-help-you/Professional-Standards-Service/PAS-2050/

Criteria	PEF Guide	ISO 14044 (2006) LCA – requirements and guidelines	ISO/DIS 14067 (2012): carbon footprint of product	ILCD Handbook – 1st Edition (2010)[117]	Ecological Footprint (2009)[118]	GHG Protocol (2011) (WRI – WBCSD)[119]	French Environmental Footprint (BPX 30-323)[120]	UK Product Carbon Footprint PAS 2050 (2011)[121]
and exclusions	environmental management, identification of environmental hotspots, environmental improvement and performance tracking; **External applications** (e.g. B2B, B2C) cover a wide range of possibilities, responding to customer and consumer demands, marketing, benchmarking, environmental labelling, etc.	improve the environmental performance of products. Comparative assertion with additional requirements. Provide information to decision makers.	consumers for decision making Performance tracking. Comparative assertion with additional requirements.	Analyse environmental life-cycle performance of products for improvement (performance tracking), comparisons, customer information (business, consumer). Including comparative assertions with additional requirements.	decision makers and consumers on consumption behavior on different levels i.e. country level, sub-regional, company.	GHG reduction opportunities. Provide GHG emissions data to business and interested stakeholders through public reporting. Additional types of communication (e.g., labels, claims) are supported by the standard with additional specifications (e.g. product rules). Comparative assertions (as defined by ISO 14044) are not supported.	consumer, allow comparison of products belonging to the same category and, when relevant, between product categories.	for internal assessment e.g.: - To facilitate evaluation of alternative product configurations or benchmarking - Performance tracking, including identifying GHG reduction opportunities - Facilitate comparison of GHG emissions from goods and services
Communication Target	B2B and B2C.	B2B and B2C.	B2B and B2C.	B2B and B2C.	Public information.	B2B and B2C.	B2C.	Does not specify requirements for

Criteria	PEF Guide	ISO 14044 (2006) LCA – requirements and guidelines	ISO/DIS 14067 (2012): carbon footprint of product	ILCD Handbook – 1st Edition (2010)[117]	Ecological Footprint (2009)[118]	GHG Protocol (2011) (WRI – WBCSD)[119]	French Environmental Footprint (BPX 30-323)[120]	UK Product Carbon Footprint PAS 2050 (2011)[121]
audience								communication.
Functional unit	The unit of analysis for a PEF study shall be defined according to the following aspects: The function(s) / service(s) provided: "what"; The magnitude of the function or service: "how much"; The duration of the service provided or service life time: "how long"; The expected level of quality: "how well". An appropriate reference flow shall be determined in relation to the unit of analysis. The quantitative input and output data collected in support of the analysis shall be calculated in relation	The functional unit shall be consistent with the goal and scope of the study. It shall be clearly defined and measureable. Having chosen the functional unit, the reference flow shall be defined.	Clearly defined and measureable.	The functional unit shall be consistent with the goal and scope of the study. It shall be clearly defined, both in terms of quantitative and qualitative aspects. Separate reference flow for supporting the data collection.	The standard itself does not provide any specific information on functional unit definition, but there are several studies using the functional unit concept based on ISO 14044.	The magnitude, duration or lifetime, and the expected level of quality of the function or service. Separate reference flow for supporting the data collection.	The functional unit is defined at the PCR-level.	Refers to the functional unit as the unit of analysis. Very little info and guidance given.

Criteria	PEF Guide	ISO 14044 (2006) LCA – requirements and guidelines	ISO/DIS 14067 (2012): carbon footprint of product	ILCD Handbook – 1st Edition (2010)[117]	Ecological Footprint (2009)[118]	GHG Protocol (2011) (WRI – WBCSD)[119]	French Environmental Footprint (BPX 30-323)[120]	UK Product Carbon Footprint PAS 2050 (2011)[121]
	to this flow.							
System boundary	The system boundaries shall include all processes linked to the product supply chain relative to the unit of analysis. Cradle-to-grave as default approach, or different if otherwise specified in PEFCRs. The processes included in the system boundaries shall be divided into **foreground processes** (i.e. core processes in the product life cycle for which direct access to information is available) and **background processes** (i.e. those processes in the product life cycle	Iterative Process: - Initial system boundaries are defined based on goal and scope of the study. - Final System Boundaries are determined after initial calculations and sensitivity analysis. […]	From raw material acquisition through to end-of-life and disposal. Allows for both cradle-to-grave and cradle-to-gate analyses.	From raw material acquisition through to end-of-life and disposal. Iterative, focused on most relevant processes. Include all relevant processes (both attributable processes and non-attributable processes).	Standard doesn't provide rules for definition of system boundaries. Requirement that the report clearly defines all activities included within system boundaries. Most product EF analyses define the "life cycle" boundaries as including activities from cradle to point of purchase.	From raw material acquisition through to end-of-life and disposal. Attributable processes required, relevant non-attributable processes recommended. Allows for both cradle -to-grave and cradle-to-gate analyses.	From raw material acquisition through to end-of-life and disposal. <u>Exclusions</u>: - Carbon offset - R&D - Transport of employees from home to workplace - Services associated with product or system (e.g. advertising,	From raw material acquisition through to end-of-life and disposal. Allows for cradle-grave and cradle to gate). Other supplementary requirements apply. System Boundary <u>Exclusions:</u> - Capital goods - Human energy inputs to processes. - Animals providing transport services - Transport of consumer to and

Criteria	PEF Guide	ISO 14044 (2006) LCA – requirements and guidelines	ISO/DIS 14067 (2012): carbon footprint of product	ILCD Handbook – 1st Edition (2010)[117]	Ecological Footprint (2009)[118]	GHG Protocol (2011) (WRI – WBCSD)[119]	French Environmental Footprint (BPX 30-323)[120]	UK Product Carbon Footprint PAS 2050 (2011)[121]
	for which no direct access to information is possible).						marketing, etc.) - Transport of consumer to and from the point of retail purchase. - Commuting of employees.	from the point of retail purchase (might be included after revision)
Cut-off	Not allowed.	Allowed – based on mass, energy, or environmental significance.	No guidance.	Cut-off criteria should consider the quantitative degree of completeness with respect to the overall environmental impacts of the product system. For comparative studies the cut-off shall also always relate to mass and energy.	No guidance.	Not allowed.	5% mass and energy and environmental impact.	5% GWP (All emissions that make a material contribution (i.e. >1% of emissions) must be included and at least 95% of total).
Impact categories	A default set of 14 mid-point impact categories shall be	Numerous environmental impacts arising	Climate change, including land use	Addresses twelve impact categories at the midpoint	Ecological Footprint values (e.g.	Climate change, including land use	LCIA methods recommended by the JRC are	Climate change, including land use

Criteria	PEF Guide	ISO 14044 (2006) LCA – requirements and guidelines	ISO/DIS 14067 (2012): carbon footprint of product	ILCD Handbook – 1st Edition (2010)[117]	Ecological Footprint (2009)[118]	GHG Protocol (2011) (WRI – WBCSD)[119]	French Environmental Footprint (BPX 30-323)[120]	UK Product Carbon Footprint PAS 2050 (2011)[121]
Life Cycle Impact Assessment (LCIA) methods	considered, unless (1) otherwise specified in the PEFCR, or (2) exclusion of certain impact categories is justified as specified in the PEF Guide. Default set of provided mid-point LCIA methods shall be used.	from the provision of products, including: - GHG emissions - Ozone Depletion Potential - Acidification potential - Eutrophication Potential - Photochemical Ozone Creation Potential - other environmental impacts e.g. resource depletion and human health	change. All GHG emissions shall be reported.	and three impact categories at the end point. The ILCD Handbook provides recommended methods both at midpoint and endpoint (for areas of protection).	global hectares)	change. The six substances under Kyoto protocol must be reported. Other substances applicable to the studied product or value chain are recommended.	followed. Impact categories are fixed by product category. Default set of provided mid-point LCIA methods shall be used.	change. All GHG emission shall be reported.

Criteria	PEF Guide	ISO 14044 (2006) LCA – requirements and guidelines	ISO/DIS 14067 (2012): carbon footprint of product	ILCD Handbook – 1st Edition (2010)[117]	Ecological Footprint (2009)[118]	GHG Protocol (2011) (WRI – WBCSD)[119]	French Environmental Footprint (BPX 30-323)[120]	UK Product Carbon Footprint PAS 2050 (2011)[121]
		(endpoint).						
Modelling approach (attributional vs. consequential)	Takes elements from both attributional and consequential modeling approaches.	Provide principle of how to calculate environmental burden associated with products. Avoid allocation is the preferable approach.	Provide principle on how to calculate GHG emissions (climate change) associated with products. Avoid allocation is preferable approach.	Attributional approach plus substitution for end-of-life and other multi-product processes. Avoid allocation is preferable approach.	Accounting approach (similar to attributional approach). Allows for process LCA, input-output or hybrid modelling.	Attributional approach, plus direct system expansion for multi-product processes and closed-loop approximation for recycling (following the requirements of the standard).	Attributional approach. Allocation rules for recycling and energy recovery are proposed per material.	Attributional approach. Avoid allocation is preferable approach.
Data quality	Data quality is assessed against the following criteria: • Technological representativeness • Geographical representativeness • Time-related representativeness • Completeness • Parameter uncertainty • Methodological Appropriateness and Consistency (i.e.	For the following criteria data quality requirements should be specified: • Time-related coverage • Geographical coverage • Technology coverage • Precision • Completeness • Consistency	Adopts ISO 14044.	Modified from ISO 14044 (applies to both primary and secondary data): • Technological representativeness, • Geographical Representativeness, • Time representativeness, • Completeness	No specific data quality requirements in the methodology. It refers to ISO 14044.	Five data quality indicators shall be used to assess data quality: -Technological representativeness -Temporal representativeness -Geographical representativeness	ADEME set up a Governance Advisory Committee for the public database. This committee also assesses data quality/Quality and critical review - Geographical representativene	Adapted from ISO 14044. No minimum data quality requirements are specified.

Criteria	PEF Guide	ISO 14044 (2006) LCA – requirements and guidelines	ISO/DIS 14067 (2012): carbon footprint of product	ILCD Handbook – 1st Edition (2010)[117]	Ecological Footprint (2009)[118]	GHG Protocol (2011) (WRI – WBCSD)[119]	French Environmental Footprint (BPX 30-323)[120]	UK Product Carbon Footprint PAS 2050 (2011)[121]
	completion of Resource Use and Emissions Profile according to this general Guide). Data quality requirements shall be met (<u>for both specific and generic data</u>) by any PEF study intended for external communication. For PEF studies (claiming to be in line with this Guide) intended for in-house applications, the specified data quality requirements should be met (i.e. are recommended), but are not mandatory. In the final Resource Use and Emissions Profile, for the processes or activities	• Sources of the data • Uncertainty of the information No minimum data quality requirements are specified. For comparative assertions, the above eight criteria shall be addressed Comparison PEF vs ISO 14044: **1. the data quality criteria (six vs eight) to a large extent cover the same aspects, but ISO goes beyond PEF.**		/ Precision, • Methodological appropriateness and consistency.		-Completeness -Reliability For significant processes, companies shall report a descriptive statement on the data sources, the data quality, and any efforts taken to improve data quality.	ss - Technological representativeness - Time-related representativeness - Completeness of the elementary flows - Precision and uncertainty - Reproducibility No minimum data quality requirements are specified.	

Criteria	PEF Guide	ISO 14044 (2006) LCA – requirements and guidelines	ISO/DIS 14067 (2012): carbon footprint of product	ILCD Handbook – 1st Edition (2010)[117]	Ecological Footprint (2009)[118]	GHG Protocol (2011) (WRI – WBCSD)[119]	French Environmental Footprint (BPX 30-323)[120]	UK Product Carbon Footprint PAS 2050 (2011)[121]
	accounting for at least 70% of contributions to each impact category (based on the screening exercise, if conducted), both specific and generic data shall achieve at least an overall "good quality" level. A semi-quantitative assessment of data quality shall be performed and reported for these processes. […] With respect to the level at which assessment of data quality shall be conducted: • For generic data, shall be conducted at the level of the input flows, e.g.	2. In the PEF, the six criteria shall always be considered, while the eight ISO criteria shall all be considered only for comparative assertions 3. PEF establishes actual minimum data quality requirements, while ISO does not.						

Criteria	PEF Guide	ISO 14044 (2006) LCA – requirements and guidelines	ISO/DIS 14067 (2012): carbon footprint of product	ILCD Handbook – 1st Edition (2010)[117]	Ecological Footprint (2009)[118]	GHG Protocol (2011) (WRI – WBCSD)[119]	French Environmental Footprint (BPX 30-323)[120]	UK Product Carbon Footprint PAS 2050 (2011)[121]
	purchased paper used in a printing office • For specific data, shall be conducted at the level of an individual process or aggregated processes, or at the level on individual input flows.							
Data type and data collection **Data collection template**	**Specific data** shall be obtained for all foreground processes and for background processes, where appropriate. However, in case generic data is more representative or appropriate than specific data (to be justified and reported) for foreground processes, generic data shall be also used for the foreground.	**Primary data:** Collected (measured, calculated or estimated) from production sites associated with the unit processes within the system boundary. **Secondary data:** Data derived from other sources such as literature or	Adopts ISO 14044.	**Primary data:** Primary data for the foreground system and main background processes preferred; secondary data can also be used, provided it is ILCD-compliant and has good and demonstrable representativeness for those	If using process LCA, **primary data** requirement/recommendation must follow ISO 14044. **Secondary data**: No specific source given. No **collection template** is	**Primary data** are required for all processes under the reporting company's ownership or control. **Secondary data:** The best quality data is recommended, with primary data preferred if available. The methodology guide acknowledges that the data	**Primary data** is preferred. Specific requirement provided at PCR-level. Provides **data collection template** for transport and for unit process in Annex E.	**Primary activity data** are required for all processes owned or operated by the implementing organisation. **Secondary data** shall be used for inputs where primary activity data have not been obtained.

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	processes. **Generic data** should be used only for processes in the background system. Generic data (provided they meet the data quality requirement specified in the PEF Guide) shall, where available, be sourced from: • Data developed in line with the requirements for the relevant PEFCRs • Data developed in line with the requirements for PEF studies • ILCD Data Network (data that comply with ILCD requirements for	databases. No specific data source is recommended. The practitioner must follow the defined data quality requirements for selecting secondary data. **Data collection template:** See ISO/TR 14049		processes/products. For all other data needs, the best quality, ILCD-compliant **secondary data** is preferred. Remaining data gaps shall be filled using "data estimates" of minimum quality. The methodology guide acknowledges that the data management plan should include a data **collection template.**	provided	management plan should include a **data collection template**. However, no example is provided in the standard.		Preference that secondary data conforms with the requirements of the PAS. Selection of secondary data shall be based on (1) Data quality rules, which are taken from ISO 14044, (2) Preference for secondary data from peer review publications, together with data from other competent sources **Collection template:** Provided in PAS 2050 guide.

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	Situation A) • ELCD **Data collection template:** the template provided is informative.							
Allocation / multifunctionality hierarchy	The following PEF multi-functionality decision hierarchy shall be applied for resolving all multi-functionality problems: (1) subdivision or system expansion; (2) allocation based on a relevant underlying physical relationship (*substitution* may apply here); (3) allocation based on some other relationship.	Allocation should first be avoided through process subdivision or system expansion where possible. If not possible, physical relationships (e.g. mass, energy) between products or functions should be used to partition inputs and outputs. When physical relationships cannot be established, other	Adopt ISO 14044.	Further developed and specified from ISO 14044: - Avoiding allocation by subdivision or virtual subdivision. - Substitution / system expansion (also of wider functions) of market mix. - Causal physical relationship	If the analysis includes a novel calculation of P-LCA data that disaggregates a finished product into its primary product equivalents, it must comply with the ISO LCA Standards 14040 and 14044.	Adapted from ISO 14044 : - Companies shall avoid allocation wherever possible by using process subdivision, redefining the functional unit, or using system expansion. - If allocation is unavoidable, companies shall allocate emissions and removals based on the underlying	Adopt ISO 14044.	Further developed from ISO 14044: 1. Co-product allocation is avoided by dividing unit processes into sub-processes, or expanding the product system. 2. If 1 is not applicable, allocation according to supplementary requirements. 3. If there are no supplementary

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		relationships shall be used instead (e.g. economic value).		allocation, e.g. mass, energy. - Economic allocation.		physical relationships between the studied product and co-product(s). - When physical relationships alone cannot be established, companies shall select either economic allocation or another allocation method that reflects other relationships between the studied product and co-product(s).		requirements, economic value is preferred.
Allocation for recycling ***For more detailed information,***	Specific guidance (including formula!) provided, also accounting for energy recovery.	This issue is addressed separately, providing general principle of avoiding allocation but no specific rule provided – no	Substitution of primary production of avoided product. It follows ISO 14044 allocation hierarchy. Annex	Substitution of market average primary production of avoided product.	No guidelines.	Either the closed-loop approximation or recycled content method shall be used. If neither method is appropriate, other methods – consistent	Provides very detailed guidance and equations for closed-loop recycling and open-loop recycling, with or	Provides equations to calculate emissions – distinguishes between recycled content method and closed-loop approximation

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see excel file prepared		formula.	C which contains the formulas is INFORMATIVE.			with ISO 14044 - may be used if disclosed and justified in the inventory report.	without energy recovery.	recycling method. (sets out criteria as to where to apply 0/100,100/0).
Fossil and biogenic carbon emissions and removals	Removals and emissions shall be reported separately for both fossil and biogenic sources.	No provisions.	Removals and emissions shall be reported separately for both fossil and biogenic sources.	Removals and emissions shall be reported separately for both fossil and biogenic sources.	No provisions.	Both carbon emissions and removals from fossil and biogenic sources are included in the inventory results and reported separately for transparency (mandatory unless not applicable).	Both carbon emissions and removals from fossil and biogenic sources should be reported separately.	Both carbon emissions and removals are included in the assessment (mandatory), except biogenic emissions and removals from food and feed (which is not mandatory).
Direct land use change / indirect land use change	Greenhouse gas emissions from direct land use change shall be allocated to goods/services for 20 years after the land use change occurs	No provision.	**Direct land use change**: Uses IPCC guidelines. **Indirect land use change**: Will be considered once an internationally	**Direct land use change**: Specific IPCC-derived guidance with default table; allocated to products for 20	**Direct land use change**: Land use types used in the Report are consistent with the National	**Direct land use change**: required when attributable. Additional guidance for calculation available, data sources refer to IPCC.	**Direct land use change**: Reference to IPCC methodology. **Indirect land use change**: Will be	**Direct land use change**: Specifically includes emissions from land use change that occurred within the past 20 years.

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	using the IPCC default values table. **Indirect Land Use Change**: shall not be included for the time being, as no accepted methodology is currently available.		agreed method has been established.	years after land use change (can be adjusted in case of better specific, reviewed data). **Indirect land use change** (ILUC) is considered under consequential modeling, but not for product level (attributional-based) LCAs.	Footprint Accounts, both for footprint and biocapacity. **Indirect land use change**: no provision.	**Indirect land use change** is not required.	considered once an internationally agreed method has been established.	**Indirect land use change** is excluded.
Carbon storage and delayed emissions	Credits associated with temporary (carbon) storage or delayed emissions shall not be considered in the calculation of the PEF for the default impact categories, unless otherwise specified in a supporting PEFCR.	No specific provision/ information provided. However, interpretation of the definition of LCA provided suggests that carbon storage and delayed emissions are excluded from	Carbon storage shall be reported separately.	Excluded from the usual scope of study. However, if included because part of the goal of study, the ILCD Handbook provides detailed operational	No provisions.	Carbon that is not released as a result of end-of-life treatment over the time period of the study is treated as stored carbon. The time period should be based on science insofar as possible, or be a minimum of 100	Biogenic and fossil carbon. Time-weighted average for storage/delay for up to 100 years. The decision of whether to apply the concept of delayed	Any impact of carbon storage is included in the inventory but must also be recorded separately. Weighting factors for delayed emissions are not included in the inventory result, but

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		the usual scope of study.		guidance. Similar to the recommended approach in the PAS 2050 for methods by which carbon storage impacts are calculated. Differentiate temporary storage from permanent storage if guaranteed for over 10000 years.		years. Delayed emissions or weighting factors (e.g. temporary carbon) shall not be included in the inventory results, but can be reported separately.	emissions is optional and will be decided in each PEFCR. GHG removal can be taken into account for products containing biomass if this biomass is derived from replanted forest.	a method is provided (in Annex B) if organisations wish to apply them. If so, this must be recorded separately to the inventory result.
Emissions off-setting	Shall not be included in the assessment.	No provisions.	Shall not be included in the assessment.	Shall not be included in the assessment.	No provisions.	Shall not be included in the assessment.	Shall not be included in the assessment.	Shall not be included in the assessment.
Review and reviewer	Unless otherwise specified in relevant policy instruments, any study intended for	Provides requirement for comparative	Establishes different verification schemes	Provides minimum requirements for review type,	Specifies that the report should be independently	Assurance is required and can be achieved through:	Secondary data not derived from recommended sources must be	Independent third party certification body accredited to provide assessment

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qualifications	external communication shall be reviewed by an independent and qualified external reviewer (or review team). A study to support a comparative assertion intended to be disclosed to the public shall be based on relevant PEFCRs and reviewed by an independent external reviewer together with a stakeholder panel. Minimum requirements on reviewer qualifications apply.	studies: If the study is intended to be used for a comparative assertion to be disclosed to the public, interested parties shall conduct this evaluation as a critical review, and provide general information as to the type of review.	depending on the nature and intended application of the study: declaration, claim, labelling.	reviewer qualifications and how to review (e.g. for a general LCA study, independent external review is a minimum requirement).	assessed, but no specific guidance provided.	- First party verification - Third party verification - Critical Review.	reviewed by committee. In the PCR, temporal validity of data and update frequency and validation process for data and results are defined.	and certification to the PAS 2050. There are other possibilities for verification, including self verification and non-accredited body verification, depending on intended communication.
Reporting	The study report shall include, at a minimum, a Summary, a Main Report, and an Annex. These shall contain all	Provides general requirements for reporting and additional requirements for	Provides general requirements (adapted from ISO 14044).	Provides general requirements for reporting and additional requirements for	No report template provided. Other	Provides a list of required and optional elements for public reporting (template available	No report template provided.	No report template provided.

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	the elements specified. Any additional supporting information can be included, e.g. a Confidential Report – (The contents of these mandatory reporting elements closely follow ISO 14044 requirements on reporting. However, if the assessment supports comparative assertions (to be disclosed to the public), ISO reporting requirements goes beyond PEF reporting requirements)	third party reporting. There is no LCA report template example in the ISO 140xx. The ISO 14048 provides the template and/or requirements for the dataset only.	Additional requirements for third party reporting: a) modifications to the initial scope together with their justification; b) description of the stages of the life cycle; c) system boundary, including type of inputs and outputs of the system as elementary flows, […]. d) description of significant unit processes,[…]	third party reporting. Provides dataset and study report format and templates. Supports electronic / web-based data exchange and workflow.	requirements apply […]	on the GHG Protocol website).		

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			e) data,[…] f) results of the interpretation, including conclusions and limitations.					
Interpretation of results	The environmental footprint interpretation phase shall include the following steps: (1) assessment of the robustness of the PEF model"; (2) "identification of hotspots"; (3) "estimation of uncertainty"; and (4) "conclusions, limitations and recommendations". Optional tool for interpretation of results: completeness	- identification of the significant issues based on the results of the LCI and LCIA phases of LCA; - an evaluation that considers completeness, sensitivity and consistency checks; - conclusions, limitations, and recommendations	Adopt ISO 14044.	Further specify from ISO 14044.	Adopt ISO 14044.	Aspects of interpretation are included in chapters on uncertainty, reporting, and performance tracking.	Adopt ISO 14044.	Adopt ISO 14044.

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	check, sensitivity check, consistency check. (these are mandatory in ISO 14044).							
Uncertainty of results	At least a qualitative description of uncertainties shall be provided. TIP: Quantitative uncertainty assessments can be calculated for variance associated with significant processes and characterisation factors using Monte Carlo simulations.	Listed as a requirement, but no detailed guidance provided. *"An analysis of results for sensitivity and uncertainty shall be conducted for studies intended to be used in comparative assertions intended to be disclosed to the public."*	Listed as a requirement, but no detailed guidance provided.	No specific method in the existing guide. Provides framework only.	No detailed guidance provided, but indicates that an estimate of the following types of uncertainty should be given separately: • Input parameters •Proportionality assumptions • Category errors •Incomplete or partial	Requires reporting on qualitative uncertainty for significant processes, Guidance and tools for performing quantitative uncertainty available as supplementary information on the GHG Protocol website.	The sector-specific working groups shall conduct uncertainty and sensitivity analysis based on ISO 14040:2006. Specific focus will be given to significant environmental aspects to ensure that the information communicated to consumers stays relevant.	Companies shall report a qualitative statement on inventory uncertainty and methodological choices. Methodological choices include: • Use and end-of-life profile • Allocation methods, including allocation due to recycling • Source of global warming potential (GWP) values used

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					coverage			• Calculation models